SERIES I. NOS. 3 & 4.

HOUGHTON FARM.

EXPERIMENT DEPARTMENT.

AGRICULTURAL PHYSICS.

1883.

METEOROLOGY

AND

SOIL TEMPERATURES.

NEW-YORK:
PRINT OF "THE HUB."
323 PEARL-STREET.

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HOUGHTON FARM.

LAWSON VALENTINE, *Proprietor.*

EXPERIMENT DEPARTMENT.

HENRY E. ALVORD, *Manager.*

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Botanist and Chemist.

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Assistant.

POST, TELEGRAPH AND EXPRESS OFFICES:

MOUNTAINVILLE, ORANGE CO., NEW-YORK.

Visitors are always welcome at Houghton Farm.

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*Resigned Sept. 1, 1883.

HOUGHTON FARM.

EXPERIMENT DEPARTMENT

SERIES I. NO. 3.

METEOROLOGY.

BY

D. P. PENHALLOW, B. SC.,

A REPORT OF OBSERVATIONS FOR TWELVE MONTHS, FROM NOVEMBER, 1882, TO OCTOBER, 1883, INCLUSIVE.

1883.

NOTE.

Prof. Penhallow closed his connection with Houghton Farm in the Autumn of 1883, but he kindly consented to edit the data collected under his supervision, during the current season.

Mr. Winthrop E. Stone (B. Sc., Mass. Agr. Col., 1882,) was the principal assistant of Prof. Penhallow, and since the resignation of the latter has been in charge of the office. The drawings, charts and tables in this pamphlet were prepared by Mr. Stone.

HENRY E. ALVORD,
Manager.

January, 1884.

METEOROLOGY,—HOUGHTON FARM,—1883.

The present report upon the meteorology of Houghton Farm is the first one issued which gives a complete record for an entire year, and at the same time enables us to institute comparisons with a previous record. The plan of experiment work, as previously announced, is based upon an equal division of the year into the summer and winter months, making the former embrace those months from May to October, inclusive. While it is essential to consider the meteorology of the year as a whole, it is desirable to make a corresponding division in this report for the purpose of exact comparison, not only of the meteorology of corresponding months, but of the meteorology and the experiments which such conditions are likely to affect.

During the winter of 1882 and 1883 there were no records of soil temperature, and as of necessity there were no other out-of-door experiments which would be influenced by atmospheric conditions, it is unnecessary to consider the meteorological conditions from November to April in a detailed manner, as suitable summaries will exhibit the important facts. It should be remarked, however, with reference to the relative humidity, that the hygrometric determinations are of little value when the temperature goes below the freezing point. Thus during the month of January, there were so many occasions when an accurate determination could not be made, although all precautions were taken, that the relative humidity for that month was not calculated, and in the summary at the end of this paper, the annual mean of relative humidity is to be taken, exactly, as that of eleven months only. The following summaries will present the winter meteorology, together with the casual phenomena for the entire year.

VELOCITY AND DIRECTION OF WIND FOR SIX MONTHS.

November to April, inclusive, 1882 and 1883.

	PER CENT. OF OBSERVATIONS.				Prevailing Direction.	Whole number of Observations.
	Less than 1 mile.	1–14 miles.	15–24 miles.	25 miles.		
November	36.5	60.0	3. 5	....	N.	85
December	37.5	61.1	1. 4	....	N. W.	72
January	28.5	68.1	3. 3	....	N. E.	91
February	34.5	63.1	2. 4	....	N. W.	84
March	36.6	62.3	1. 1	....	N. W.	93
April	42.8	56.2	1. 0	....	S. W.	89
Totals and Means	36.6	61.8	2.12	....	N. W.	514

TABLE OF STORMS AND RAINFALL FOR SIX MONTHS.

November, 1882, to April, 1883, inclusive.

	Number of Storms	Date.	Depth of Snow.	Rain and Melted Snow.	Per cent. Rainfall.	Rel. Hum. Per cent.
November	4	13, 17, 26, 29.	1.5 in.	1.11	7. 1	73
December	6	6, 7, 10, 11, 13, 21.	5 in.	1.51	9. 6	76
January	13	1, 5, 8, 10, 13, 16, 17, 18, 19, 20, 28, 29, 31.	10.8 in.	4.10	26. 1	—
February	8	3, 6, 7, 11, 14, 15, 18, 24.	9.8 in.	3.31	21. 2	75
March	5	6, 10, 20, 27, 30.	7.8 in.	1.92	12. 2	68
April	10	7, 12, 16, 17, 20, 22, 23, 27, 28, 29.	....	3.73	23. 8	68
Totals	46		34.9 in.	15.68	100.00	72

CASUAL PHENOMENA, 1882–83.

	AURORAS.	SOLAR HALOS.	LUNAR HALOS.	RAINBOWS.
November	12, 14, 18, 19, 20th	....	21st	....
December	15th	....	20th	27th
January	....	....	....	....
February	26th and 28th	....	....	....
March	8th	....	16th and 22d	....
April	3d and 24th	....	....	....
May	....	18th	....	....
June	....	....	....	13th
July	29th and 50th	....	....	....
August	....	15th	....	....
September	....	20th	14th and 19th	....
October	....	....	....	....
Totals	14	3	6	2

SUMMER MONTHS.

WINDS.

During the last season the winds have been found to prevail from a southern quarter, and in no case has the prevailing wind for a month been in a northerly and easterly quarter. In this respect, therefore, we observe a contrast with the prevailing winds of 1882, which for the six months blew from W.S.W., and during two of those months from north and east.

Our figures show that, in 1883, 36.8 per cent. of the observations were taken when there was no wind; 61.6 per cent. when the wind ranged from one (1) to fourteen (14) miles per hour; 1.6 per cent. when it ranged from fifteen (15) to twenty-four (24) miles, and 0 per cent. when it exceeded this. Compare these figures with those for 1882, which give 0.; 96.40; 1.89 and 1.71 per cent. respectively, and we find a marked difference, showing that during the season just passed, the strong winds have been much less prevalent; that violent winds have been rare, and that calms have been numerous. The most violent wind of the entire season was experienced on the fourth of July, from 12 M. to 1 P. M. About noon of that day, heavy clouds approached from the west, and as they

came over the valley from the summit of Schunemunk, heavy rain commenced to fall, while the lightning became sharp and frequent, and the thunder heavy. The wind, which had been freshening, soon developed into a gale, and at about 12.30 attained an estimated velocity of 50 miles an hour. It also assumed the character of a tornado, the circular movement of the wind being well defined from the directions to which small trees were bent under its influence. After the storm was over, it was found that it passed about due east, its track being about one and a half miles in width, and as the southern boundary was a short distance north of the observing station, there were, unfortunately, no records of the heavy fall of rain, and all of the data were secured by accidental circumstances. The action of the wind was so powerful, that large trees were uprooted all along the track of the storm, while other trees had their tops broken and twisted off in a very effective manner. No buildings were damaged, so far as could be learned, and this may have been due to the great area over which the cyclonic movement was distributed. The development of a storm of this peculiar character in such a broken and even mountainous section, seemed to be a matter of special interest. The movement undoubtedly generated at some distance to the west of our position, its approach lying over a much more level and open country.

Intermediate observations enabled us to determine a few other cases of strong wind. Sept. 3d the wind freshened during the morning until it attained a velocity of about 35 miles, but it died away before noon. Again, on the 25th of the same month, a heavy wind blowing 30 miles an hour, immediately followed a light rain. There was an accompanying low temperature and very low barometer. October 2d, a high wind developed in connection with rain, blowing 30–35 miles per hour. The following table will show the force and direction of winds for the six months now under consideration.

VELOCITY AND DIRECTION OF WIND FOR SIX MONTHS.

May to October, 1883, inclusive.

	PER CENT. OF OBSERVATIONS.				Prevailing Directions.	Whole number of Observations.
	Less than 1 mile.	1–14 miles.	15–24 miles.	25 miles.		
May	28.6	68.9	2.3	0.0	S.	87
June	43.8	56.1	0.0	0.0	S.	89
July	27.1	72.8	0.0	0.0	S.	92
August	36.7	62.0	1.3	0.0	S. by W.	87
September	40.0	57.7	2.3	0.0	S. W.	90
October	44.4	52.2	3.4	0.0	W.	90
Means and Totals	36.8	61.6	1.6	0.0	S. by W.	535

STORMS AND RAINFALL.

During the past season no special attempt has been made to classify the thunder storms, and exactly determine the number of deflections from their original course through the influence of local peculiarities of the earth's surface, though it may be stated that, in general, the same deflections have been observed

as were recorded last year. The effect of these deflections in the promotion of drought, however, has not been so marked during the season of 1883, because of the more general distribution of rain through the entire season. As will be seen from the following table, there were 47 storms in all, during the six months, and they were distributed with great uniformity, thus being in striking contrast with those of the preceding year.

The total rainfall for the season of 1883 was 22.9 inches against 33.27 inches in 1882, but we have to bear in mind the excessive rains in September of the latter year, which alone amounted to very nearly one-half the total. Making due allowance for this, we find the precipitation for 1883 to have been well up to the average, and in its distribution through the season, much more favorable to healthy growth of vegetation, since we find that a little more than half the precipitation (57.73 per cent.) occurred in the dry months of June, July and August. In May there were 2.83 inches of rain against 7.21 for the same month of 1882; in June, 4.92 against 3.90; July, 5.39 against 2.19; August, 2.91 instead of only 0.99 in 1882; September, 2.27 against 16.56, and in October, 4.58 instead of 2.42 inches. In May the rain was distributed through eight storms, thus making the month one generally favorable to planting, and free from the rotting of seed which was such a source of complaint the year before. Vegetation grew well through the entire season, and did not receive any material check from either drought or flood. Viewing the season as a whole, so far as the precipitation was concerned, it was a most favorable one. The following table will exhibit the detail in this connection :

STORMS AND RAINFALL FOR SIX MONTHS.

May to October, 1883, inclusive.

	Number of Storms.	Date.	Rainfall.	Per cent. of Rain.	Per cent. Rel. Hum.
May	8	4, 5, 8, 11, 14, 15, 21, 22, 31.	2.83 in.	12.35	61
June	9	3, 6, 7, 10, 13, 18, 28, 29, 30.	4.92 in.	21.50	70
July	10	2, 4, 5, 8, 12, 15, 17, 22, 28, 31.	5.39 in.	23.53	72
August	6	2, 13, 18, 19, 20, 23.	2.91 in.	12.70	69
September	7	4, 8, 13, 17, 24, 28, 30.	2.27 in.	9.91	71
October	7	2, 6, 13, 20, 24, 26, 29.	4.58 in.	20.00	76
	47		22.90 in.	99.99	70

HUMIDITY.

The relative humidity for the six months shows a mean of 70 per cent., thus only one per cent. lower than for the previous year. The humidity of the atmosphere was not subject to these extreme variations noticed in 1882. The greatest general elevation of temperature occurred in June, but the effect of this, combined with the humid atmosphere was to highly stimulate the growth of vegetation. Beyond this, there was nothing specially noteworthy in the con-

ditions of the atmosphere, and it only remains to note that, taking the season as a whole, the conditions were much less favorable for the development of parasites and debilitated growth of plants than was 1882; in fact, we might say with truth, that the conditions were most favorable to healthy vegetation.

FROSTS.

Several frosts were reported during the summer, though not in our immediate vicinity. August 6th, a rather sharp frost was reported from Delaware County, but it did little or no damage, so far as could be learned. Local frost was first felt September 4th, and followed by others on the 11th and 27th. They were all light and caused little or no damage. The first severe frost was experienced October 4th, followed by still harder ones on the 5th and 6th, the last causing ice to form ¼ of an inch thick. Geese were observed flying southward on the 27th, and crickets and katydids were last heard about the middle of the month, doubtless having been quieted by the hard frosts of the 17th, when the ground was frozen quite hard. Vegetation, except in a few cases, such as *Lepidium Virginicum* (Pepper-grass) and *Taraxacum dens-leonis* (Dandelion) was effectually checked by the very hard frosts of the 17th, 18th and 19th. It will thus be seen that the season closed fully two weeks earlier than in 1882, and was more favorable to the early and full maturity of vegetation in general, so that we might be justified in the anticipation of fewer complaints of winter killing from unripened wood.

HALOS AND AURORAS.

Auroras have been rather more numerous during the past season than in 1882; and for the entire year from the previous November, fourteen in all were observed. Only three solar halos have been noticed, and they occurred May 18th, August 15th and September 20th. Of lunar halos there have been six during the entire year, occurring November 21st, December 20th, March 16th and 22d, and September 14th and 19th. Rainbows were observed only twice, December 27th and June 13th.

Appended is a table showing the times of sunrise and sunset as observed at the different thermometers, and from these figures an idea will be gained of the shortening of the day because of the surrounding mountains.

TIMES OF APPEARANCE AND DISAPPEARANCE OF THE SUN AT THE THERMOMETER PLOTS.

Mercurial.

May 11th.	Sunset	5.45 P. M.
" 18th.	Sunset	6.05 P. M.
Aug. 7th.	Sunset	6.05 P. M.
" 26th.	Sunrise	6.15 A. M.
" "	Sunset	5.40 P. M.
Sept. 5th.	Sunset	5.30 P. M.
" 26th.	Sunset	4.55 P. M.
Oct. 26th.	Sunrise	7.10 A. M.
" "	Sunset	4.15 P. M.
" 30th.	Sunset	4.00 P. M.

Thermo-electric.

(NOTE.—Buildings shade the location of this apparatus till late in the forenoon, at certain seasons.)

Sept. 6th.	Sunrise	9.20 A. M.
" "	Sunset	5.20 P. M.
" 26th.	Sunrise	10.00 A. M.
" "	Sunset	4.50 P. M.
Oct. 26th.	Sunrise	10.00 A. M.
" "	Sunset	4.00 P. M.

SUMMARY OF METEOROLOGICAL OBSERVATIONS.

(November, 1882, to April, 1883, inclusive.)

Lat. 41° 21′ N. Long. 4 h. 56 m. from Greenwich. Total elevation, 66.438 M. = 218 ft.

	TEMPERATURE OF AIR.											BAROMETER. Reduced to 32° Fah.				HYGROMETER. Rel. Humidity.				PLUVIOMETER. Depth of Rain.	
					Means of			Absolute Max.		Absolute Min.											
	A. M. 7	P. M. 2	P. M. 9	Means.	Daily Max.	Daily Min.	Daily Range	Temp.	Date.	Temp.	Date.	A. M. 7	P. M. 2	P. M. 9	Means.	A. M. 7	P. M. 2	P. M. 9	Means.	Depth of Water.	Date of Greatest Fall.
November......	33.9	4.51	37.2	39.1	47.3	28.7	18.2	73	12th	5.0	28th	29.86	29.81	29.84	29.84	83	60	73	73	1.11	27th, 0.47 in.
December......	26.2	30.2	26.1	27.2	33.8	18.6	15.2	47	6th	2.5	4th	29.77	29.74	29.78	29.75	78	71	80	76	0.70	11th, 0.36 in.
January........	19.2	25.3	22.2	21.9	29.5	12.7	15.7	44	21st	2.5	23d	29.87	29.83	29.88	29.86	—	—	—	—	4.10	28th, 0.62 in.
February......	24.8	32.1	26.9	27.6	36.3	17.2	19.1	47.5	25th	2.0	15th	29.92	29.88	29.94	29.91	80	71	74	75	3.31	6th, 0.74 in.
March.........	25.0	35.4	29.7	30.4	36.2	19.9	19.2	60.0	18th	1.5	19th	29.66	29.59	29.63	29.64	77	53	74	68	1.92	10th, 0.72 in.
April..........	40.0	51.6	43.1	45.6	55.2	34.2	21.1	68.	19th	19.0	3d	29.72	29.67	29.68	29.69	75	54	76	68	3.73	17th, 1.15 in.
Means.........	38.2	36.6	30.9	31.9	39.7	21.9	18.1	56.6		3.8		29.80	29.75	29.79	29.78	79	62	75	72	14.87	

(May to October, 1883, inclusive.)

	TEMPERATURE OF AIR.											BAROMETER. Reduced to 32° Fah.				HYGROMETER. Rel. Humidity.				PLUVIOMETER. Depth of Rain.	
					Means of			Absolute Max.		Absolute Min.											
	A. M. 7	P. M. 2	P. M. 9	Means.	Daily Max.	Daily Min.	Daily Range.	Temp.	Date.	Temp.	Date.	A. M. 7	P. M. 2	P. M. 9	Means.	A. M. 7	P. M. 2	P. M. 9	Means.	Depth of Water.	Date of Greatest Fall.
May...........	54.3	67.8	56.3	58.5	70.2	45.8	24.3	83.0	26th	31.0	14th	29.66	29.63	29.65	29.65	70	48	64	61	2.83	22d, 1.22 in.
June...........	66.8	77.4	65.9	68.8	80.9	58.4	22.5	90.0	6th	41.0	2d	29.68	29.63	29.64	29.65	78	57	77	70	4.92	28th, 2.01 in.
July...........	67.4	79.3	67.3	70.4	83.3	57.9	25.4	93.0	4th	48.0	1st	29.68	29.63	29.65	29.66	79	56	81	72	5.39	8th, 1.16 in.
August........	61.6	77.9	62.9	66.3	79.9	53.3	26.0	90.5	20th	39.0	28th	29.74	29.69	29.73	29.72	80	48	79	69	2.91	2d, 0.9 in.
September......	53.6	69.9	57.7	59.9	72.9	47.4	25.3	83.8	2d	31.0	10th	29.79	29.73	29.76	29.76	83	54	78	71	2.27	13th, 1.01 in.
October........	44.2	57.4	46.1	48.1	60.8	37.8	22.0	83.0	14th	20.0	17th	29.85	29.80	29.85	29.83	87	63	79	76	4.58	29th, 1.73 in.
Means.........	57.9	71.6	59.4	62.0	74.0	50.1	24.3	87.2		35.0		29.73	29.68	29.71	29.71	79	54	76	70	22.90	
Yearly Means...	43.0	54.1	45.1	46.9	56.8	36.0	21.2	71.9		19.4		29.76	29.71	29.75	29.74	79	58	75	71	37.77	

HOUGHTON FARM.

EXPERIMENT DEPARTMENT.

SERIES I. NO. 4.

SOIL TEMPERATURES.

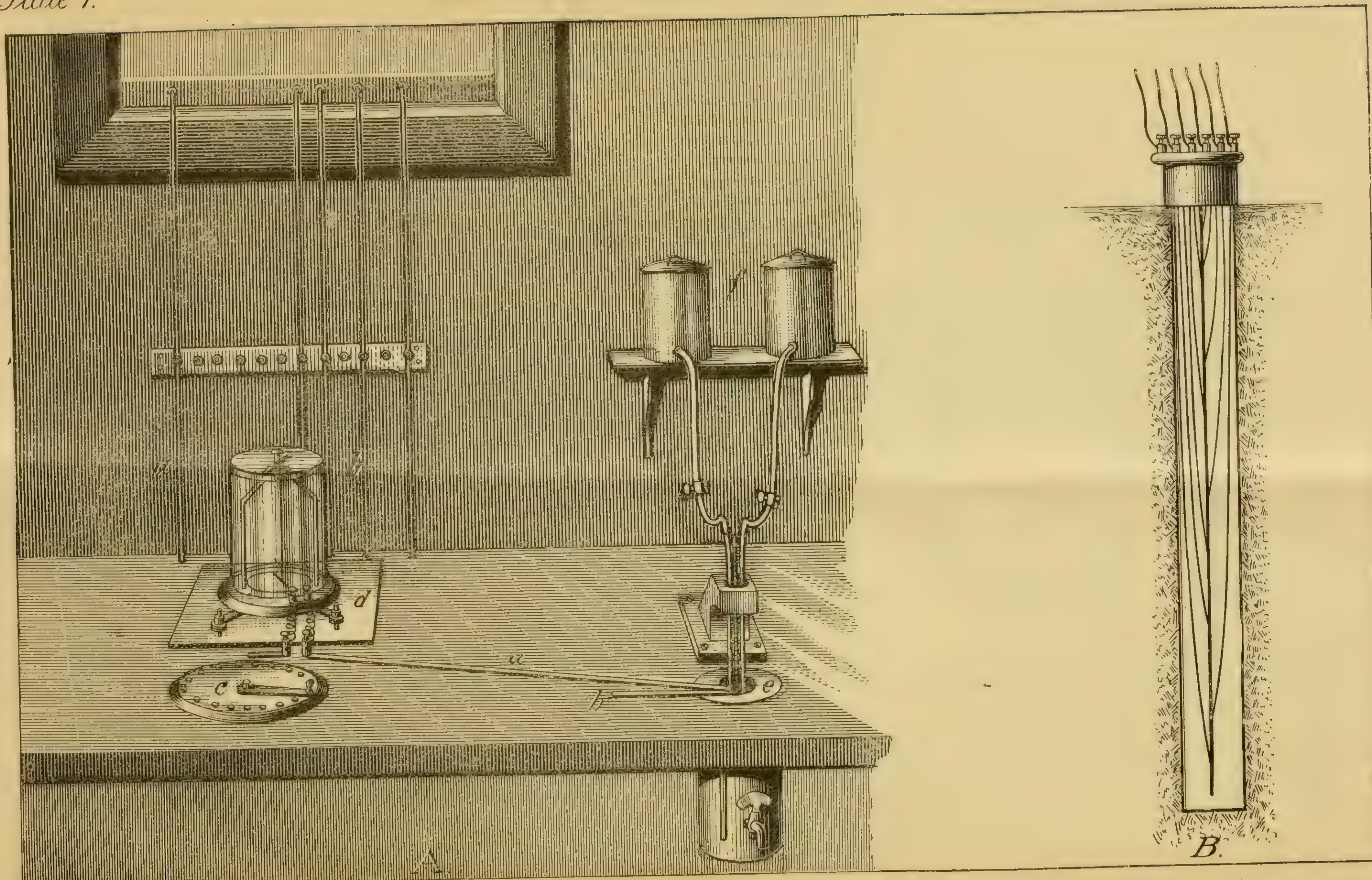
BY

D. P. PENHALLOW, B. SC.

A REPORT OF OBSERVATIONS FOR THE SIX MONTHS FROM MAY TO OCTOBER, INCLUSIVE.

1883.

Plate 1.



Electric Thermometer.

SOIL TEMPERATURES.

INSTRUMENTS.

The work of the past season has been carried on in extension of that already reported upon for 1882. It has therefore involved the use of the mercurial thermometers which were found to work so admirably, and necessarily covered the same ground as before, the thermometers being placed in exactly the same tubes, which had not been withdrawn from the soil, and the same course of observations and record being followed, with such slight modifications as experience seemed to render advisable.

In order to facilitate the work of obtaining a complete record of soil temperatures, as well as for the purpose of discovering an instrument which would combine greater accuracy, facility of reading and ease in transportation from one position to another, recourse was had to an electrical thermometer, the construction being based upon Becquerel's instrument, of which it is essentially but a modification. The construction of the apparatus is as follows:

As many thermo-couples were formed as it was deemed probable would be needed, by soldering copper wires to an iron wire at such intervals as would correspond to the depths at which it was desired to determine the temperature. All the wires were of No. 8 gauge. In all there were twelve (12) copper wires soldered to the one iron wire, thus making as many couples, separated from each other by spaces of three inches and one foot, according to the position they were to occupy in the ground. The bundle of wires thus arranged was then enclosed in a thin metal tube (Plate I, B), having a diameter of two inches and a length of eight feet six inches. In order to fully secure the wires in position, the iron wire forming the center of the bundle was stepped into the wooden plug which closed the lower end of the tube. The upper end of each wire then passed through a thick wooden cap, covering the upper and exposed end of the tube, the disposition being such that the iron wire was central, and the copper wires arranged in a circle about it. The extremities of the wires were further riveted, each to a binding post, which in turn was numbered for convenience of reference and identity. The wooden plug which closed the lower end of the tube, was fitted in so as to make a water tight joint, and after the whole apparatus was complete, it was further rendered impervious by soaking in linseed oil for twenty-four hours and coating with rubber.

When the wires were all in place in the tube, the latter was filled with fine and perfectly dry white sand. The wooden cap already referred to, was then secured in position, and connection made between the ends of the wires and the corresponding binding posts. The cap itself was made four inches thick and five inches in diameter, thus guarding against radiation of heat from the end of tube at the surface of the ground. The cap was also painted white for obvious reasons, and both it and its joints with the pipe rendered water tight. Furthermore, its relation to the tube and the wires was such that, when the whole was in position in the ground, its lower surface would just come in contact with the surface of the ground. The wires were so placed in the tube that, when the latter should be in position in the manner just specified, the first thermo-couple would be at the surface of the ground—more exactly, one-half inch below—while the other couples were separated from it and each other by regular distances, thus giving the following series of depths at which temperatures could be obtained:—Surface, 3, 6, 9 and 12 inches; 2, 3, 4, 5, 6, 7 and 8 feet.* All the copper wires were thoroughly insulated throughout, before being inclosed, and every precaution was taken to guard against the possibility of short circuiting. The operations of the instrument seem to justify us in the belief that this object has been fully attained. With the thermo-couples in this very compact form, it is possible to plant them in the soil whenever temperatures are required, and the readings are then made for any depth at which there is a couple, by making an office connection through as many wires as there are couples, plus one iron wire to complete the circuit. It will thus be apparent that, while the observations of temperature are made *in the office*, the thermo-couples may be at any distance required. It simply has to be kept in mind that, as the resistance increases with the length of the circuit, there is a limit to the effective working distance which separates the two parts of the instrument. During the past summer, readings have been taken over an air distance of 105 feet with perfect ease, and doubtless there would be no difficulty in operating over 500 feet of wire. The difficulty to be contended with here, is the extreme feebleness of the current, which of course is generated solely by the varying degrees of temperature to which the opposite terminals are exposed; hence a slight increase of resistance beyond a certain limit might render it impossible to correctly read the deflections of the galvanometer needle by which the temperature is determined.

The office portion of the instrument (Plate I, A) consists of several parts. At *e* is seen a small well containing a thermo-couple exactly similar to those in the soil, which forms the office end of the full circuit. The iron wire *a* from this couple, connects with a very sensitive galvanometer *d*, from which it again passes on and out through the window to connect with the apparatus in the soil. The copper wire *b*, from the same couple, connects directly with the key post of a switch board *c*. With the isolated binding posts of the latter, there are connected as many copper wires as there are couples in use, the wires passing out of the window and connecting, each with a binding post of the apparatus in the soil. Thus the galvanometer being in the line of iron wire is always in circuit, while the circuit may be completed through any one of the copper wires; hence through any couple, at will, by simply moving the key of the switch-board as desired.

*Equal to 7.6; 15.2; 22.8; 30.4; 60.8 and 91.2 centimeters, and 1.21; 1.52; 1.82; 2.12 and 2.43 meters.

The switch-board is of the most simple construction, consisting of a circular piece of black walnut of convenient diameter, in the center of which is placed the key post, with the other binding posts distributed in a circle at regular intervals about the circumference.

The galvanometer is really the essential part of the instrument, since upon its delicacy will depend the value of the observation. On account of the feebleness of the current, this instrument must be of the most sensitive kind. The one in use by us has an astatic needle, hung by an unspun thread of silk.

The well *e* into which the office terminal dips, is designed for the use of water, by means of which the current shall be set in operation, or balanced as desired. The one in use was formed of oak by simply boring out a core two inches in diameter and several inches deep. The walls and bottom are of considerable thickness, to avoid uncontrollable changes in the temperature of the contained water. Near the bottom there is a stop-cock for discharge, and from near the top a small glass tube extends outward and downward to serve as an overflow pipe. From a support directly over the well, there are suspended a thermometer and two glass tubes for the introduction of hot and cold water. The thermometer has a long bulb and open scale, being sensitive in its action, and easily read to tenths of a degree Centigrade. The bulb is introduced into the well so that it is brought into the same horizontal plane with the thermo couple. The glass tubes enter the well and terminate, one just above the couple—cold water—and the other just below the couple—hot water. Rubber tubes provided with clamps, connect their upper ends with two copper vessels placed upon a high shelf, one containing warm water, the other ice water.

When a given circuit is closed, so long as the couples at each end, *i. e.*, in the soil and in the office, are subjected to the same temperature, the needle of the galvanometer will show no deflection, but stand constantly at zero of the scale. As soon, however, as the couples are exposed to unequal temperatures, the needle is deflected to the right or left according to which terminal is warmest, the direction of deflection always being the same for the same relation of temperatures at opposite ends of the circuit. Again, the degree of deflection is proportioned to the difference of temperature between the two terminals, the greater the difference of temperature the greater the deflection. Theoretically, therefore, it would be possible to determine the temperature of the soil by noting the absolute deflection of the needle, and comparing this with a table of values previously determined by experiment. Practically, this is not possible, as there are too many other considerations which interfere, and another method is found to be much better in all respects. As practiced the past year, the readings were taken as follows :—

A given circuit is closed and the direction of deflection in the galvanometer noted. According to the movement of the needle, hot or cold water is gradually introduced into the well, until the couple therein is brought to the same temperature as that in the soil. This condition is determined when the galvanometer needle swings to zero and stops there. As soon as that occurs, read the thermometer in the well, and that temperature so obtained will be the temperature of the soil at the depth operated upon. This method is expeditious after one is in practice, and is quite accurate if due care is observed in the various operations.

The operation of the instrument during the past season has demonstrated its value in many ways, but being a new instrument to deal with, there were several little practical difficulties which could hardly be anticipated, and had to be met and overcome as they developed. As others may have occasion to use similar instruments, it will be well to point out some of the principal difficulties encountered, and the method of overcoming them.

First of all, it was necessary that two observers should operate during the day, as the readings were taken hourly, and it was soon discovered that there was an appreciable personal equation. Of course no remedy was possible in this case, beyond the exercise of the greatest care in order to reduce that equation to the lowest terms.

Another important source of error arose from the great care and very close scrutiny required in reading the deflections of the needle. The latter moved over a plate about three inches in diameter, but the divisions of the scale were quite close, and close attention was necessary for an accurate reading. To render this less difficult, and therefore the liability to error less, Mr. W. E. Stone, formerly assistant and now in charge of the office work, (Expt. Dept., H. F.) enlarged the scale plate by the addition of a graduated circle of paper. The length of the needle was then extended about an inch, by means of a fine filament of blackened glass. In this way it became easy to fix the position of the needle exactly. A third difficulty was found in thoroughly securing the insulation of the wires and parts of the instrument exposed to the atmosphere. The fact that the instrument worked well during pleasant and dry weather, but often behaved badly when the air was very heavily loaded with moisture, would indicate the trouble to lie (1) in the parts exposed to the air, and (2) to be due to imperfections of insulation. With these obstacles overcome, it is believed another season will more fully demonstrate the special value of the instrument.

TEMPERATURES.

The details of observation were the same during the past season as in 1882; therefore, in first considering the record of the mercurial thermometers, we will take up the various points for discussion and comparison in the same order as given in our last report. All the results given this year are to be regarded as based upon the twelve hours' observation from 8 A. M. to 7 P. M., inclusive, unless otherwise specified. Also, for the sake of exact comparison, the results for 1882 have been recalculated upon the same basis, and the principal ones will be introduced.

HOURLY VARIATIONS.

General depressions of the hourly variations of temperature were found last year to be proportional to the humidity of the soil. The greater the humidity and the longer continued, the greater and more continued would be the resulting depression of variations; in other words, the effect of water in the soil is to reduce the extremes of temperature and thereby render the latter more uniform. Of course, this law is well known; it naturally follows from the relation of water to the absorption and radiation of heat, but it is desirable to give it

prominence in this connection. It is hardly worth while to devote much time and space to showing by figures the confirmatory results obtained this year, and it will suffice to say that, while the waves of general depression in hourly variations were not so frequent or long continued during the past year as in 1882, those which were developed, were caused by water in the soil, and in their relation to rainfall and conditions of humidity, fully confirm the results as previously announced.

*During the month of May, there were in all, fourteen cases of sudden depression of temperature, and one case of sudden elevation without a previous depression. The first depression occurred on the 2d, when there was a decline of 2° (3.6° F) from 2 to 3 P. M., caused simply by rapid radiation. On the following day there was a sudden depression of 4.5° (8.1° F.) between 2 and 3 o'clock, which was directly due to obscuration of the sun by heavy clouds. Again on the 11th, a fall of 3° (5.4° F.) occurred as the direct result of combined obscuration and rain. On the 14th there was a marked depression of 4° (7.2° F.) between the hours of 12 and 1 P. M., due wholly to obscuration. Two days after, there was a sudden fall of 2° (3.6° F.) about 1 o'clock, as the result of heavy obscuration, followed by a marked rise of 5° (9° F.) as the sun again became clear. On the 17th, a depression of 4.5° (8.1° F.) between 3 and 4 o'clock, was attributable to no well defined cause, unless it were rapid radiation, which had a strong tendency to accelerate at that hour, after considerable elevation during the noon hours. Again, on the next day, there was a similar depression of 4.0° (7.2° F.) at the same hour, probably to be accounted for in a similar manner, though in this case there was a strongly developed solar halo at the time of depression. And so to avoid undue repetition where the cases present such marked similarity, we may summarize the causes of depression as follows :

2. Obscuration and rain.
8. Obscuration.
4. Rapid radiation towards the close of day.

The sudden rise of 3.5° (6.3° F.) already referred to, was directly due to rapid breaking of clouds after a rain, during which there was a general depression of temperature.

Comparing these results with those of the previous May, we find that the whole number of depressions observed was greater the past season as 1: 1.75. This increase, furthermore, is found to correspond, inversely, to the relative amount of water in the soil, since we find that in May, 1882, there were 7.21 inches of rain and only 2.83 inches during the same month of the present year. We must not attach too much importance to the relation thus exhibited in this particular case, as we shall see later on. In 1882, the causes of depression were equally divided between obscuration and rapid radiation from the surface layers, there being four in each case; while in 1883 we find the depressions from obscuration to be twice as many as those due to rapid radiation. In 1882 the mean of the absolute depressions was found to be 4.6° (8.3° F.), while for May 1883 the mean was 1.6° (2.9° F.) less, or only 3.0° (5.4° F.).

*It is to be kept in mind that hourly variations refer to the surface, except where specified.

The month of June showed twenty well-defined cases of sudden depression. The first instance occurred on the 1st, and was due directly to heavy obscuration, the depression amounting to 6° (10.8° F.). Other depressions ranged from 1.4° (2.5° F.) to 8.5° (15.3° F.) but a summary shows that the causes might be distributed as follows:

5. Obscuration and rain.
15. Obscuration.

During the previous June there was a total of nine depressions, the ratio for 1882 and 1883 thus being as 1:2.2. The relation to rainfall will be seen when we compare a precipitation of 4.92 inches in 1882 against 3.90 in 1883. For the same month of the former year, the mean of all the depressions was found to be 5.8° (10.4° F.) while in 1883 it was only 3.9°, (7° F.) a difference which is seen to correspond pretty closely with the relation found between the months of May.

July gave 13 instances of sudden depression, ranging from 1.5° (2.7° F.) to an extreme of 9°. (16.2° F.) The causes were :

3. Obscuration and rain.
9. Obscuration.
1. Unknown.

The last case, for which there was no obvious cause, occurred at noon, and may have been simply one of those cases of rapid radiation which often occur when the temperature at the surface becomes elevated to a degree out of proportion to that of the layers below, and especially when this occurs about or soon after the time when the sun commences to decline.

July 1882 gave only three cases of depression, the ratio with 1883 thus being as 1:4.3. Here we observe a direct relation to the rainfall, since in July of 1882 there were 2.19 inches of precipitation and 5.39 inches in 1883. Of the causes, we find 3 depressions out of the four in 1882, due to obscuration, while in 1883, twelve out of the thirteen were due to the same cause. The mean of the absolute depressions in 1882 was 6.3° (11.3° F.) and in 1883 it was only 4.3°, (7.7° F.) again showing that, with more frequent depressions, the tendency to extremes was strongly modified.

August also had thirteen cases of depression, the degree varying from 1.5° (2.7° F.) to 11.5°. (20.7° F.) This is an excess of nine depressions over 1882, as in that year there were only four cases for August, the ratio of 1882 to 1883 thus being as 1:3.25. Comparing the rainfalls for these months, we find a precipitation of 0.99 of an inch in 1882, against 2.91 inches in 1883; or a ratio of 1:2.90. The causes of depression for the past August were found to be :

2. Obscuration and rain.
10. Obscuration.
1. Unknown.

In September there were ten well-defined cases of sudden depression, ranging

from 2.2° (3.9°F.) to an extreme of 10.8° (19.4°F.). The latter is one of the extreme cases, of which there were few instances, where the depression was largely or wholly due to the excessive elevation of the surface temperature above that of the layers below. As in previous months, however, obscuration formed a most important factor. The causes of depression were:

1. Obscuration and rain.
5. Obscuration.
4. Excessive elevation of the surface temperature.

In 1882 there were no well-defined cases of sudden depression of temperature, though there were several instances where variations could be directly traced to solar obscuration. A comparison of rainfall for the two months shows 16.56 inches of precipitation in September, 1882 against 2.27 for 1883, or a ratio of 1:.06.

In October there were only six cases of sudden depression of temperature, the range of depression being from 2.0° (3.6° F.) to 6.4°. (11.5° F.) The last temperature was the greatest depression observed, and was also the last of all, occurring on the 13th. It was also observed to be due to excessive elevation of the surface temperature above that of the strata below. The causes of depression were found to be

5. Obscuration.
1. Excessive elevation of surface temperature.

For the same month of the previous year, there was only one case of sudden depression noted, and that occurred on the 4th of the month. The ratio for the two years is thus as 1:6. An examination of the rainfall shows a precipitation of 2.12 inches in October 1882, and 4.58 inches during the same month of 1883, or a ratio of 1:189.

A summary of these facts will show that for the past year, the greatest influence in promoting sudden depressions has been solar obscuration, while next to that, and in some cases fully as important, was the establishment of what might be termed an unstable equilibrium of temperature through excessive elevation at the surface, thus rendering its displacement by slight, disturbing causes, very probable. The causes are found to have occurred in the following order:

47. Obscuration.
3. Obscuration and rain.
4. Excessive elevation of surface temperature.
4. Rapid radiation towards the close of day.
2. Unknown.
70. Total.

The following table will enable us to compare these depressions and their causes, with each other and the rainfall for the two seasons.

	May.		June.		July.		August.		September.		October.	
	1882.	1883.	1882.	1883.	1882.	1883.	1882.	1883.	1882.	1883.	1882.	1883.
Obscuration	3	8	4	15	3	9	3	10	..	5	..	5
Obscuration and Rain	1	2	..	5	..	3	..	2	..	1	..	..
Excessive Elevation of Temperature.	4	..	5	..	1	..	..	..	..	4	..	1
Rapid Radiation	..	4	..	..	..	..	1	..	..	..	..	..
Unknown	..	..	..	..	..	1	..	1	..	..	1	..
Totals	8	14	9	20	4	13	3	13	0	10	1	6
Rainfall, inches	7.21	2.83	3.9	4.92	2.19	5.39	0.99	2.91	16.56	2.27	2.42	4.58
Means of Depression, ° C.	4.6	3.0	5.8	3.9	6.3	4.3	6.62	3.27	0.0	5.97	4.90	4.44
" " ° F.	8.3	5.4	10.4	7.0	11.3	7.7	11.9	5.9	0.0	10.7	8.8	8.0

From these summaries we have to observe several important considerations.

1. That obscuration of the sun by checking absorption of heat by the soil, is a most important factor in developing sudden variations in surface temperature, the sum of the results for 1882 and 1883 showing that 65 out of 101 cases were due to this cause alone; or, if we add, as we probably should, those cases observed when there was combined obscuration and rain, then this number will be increased to 79.

2. That while the depressions were more numerous for every month of 1883, the monthly means of the absolute depressions will be seen to be much less in every month except one, and this we shall find is coincident with a more equal distribution of rainfall through the season. This relation may be expressed as follows:

	1882.	1883.
Mean monthly rainfall, inches,	5.54	3.82
Monthly mean of absolute depressions, °C,	4.70	4.14
" " " " °F,	8.46	7.45

We cannot, however, draw too close a comparison here, as we must remember the abnormal rainfall of Sept., 1882, which of course brings up the monthly mean. Exactly, therefore, we must make comparisons by months.

3d. That so far as the causes of depression are concerned, the observations for the past year confirm those for 1882.

It was observed both this year and last, that a sudden depression of temperature may be succeeded by a gradual rise, even when the conditions of depression remain, as when the sky becomes generally overcast, for then the radiation is checked, and surface temperature is augmented by absorption of heat from the lower layers of soil, or the general temperature of the soil may increase if the obscuration occur before noon. Also, when strong, the influence of de-

pression in temperature at the surface, is often felt to a depth of 16 c. m. (6.2 in.) or more.

Comparing the hourly variations for the two seasons, we find them considerably larger for every month of 1883 than for the same months of 1882, with the exception of June. The following table will show this sufficiently.

MEAN HOURLY VARIATIONS OF TEMPERATURE.

From 7 A. M. to 7 P. M.

	VARIATIONS.						RATIOS.					
	Air.	Surface	7.6 c. m. (3 in.)	15.2 c. m. (6 in.)	22.8 c. m. (9 in.)	30.4 c. m. (1 ft.)	30.4 c. m. (1 ft.)	22.8 c. m. (9 in.)	15.2 c. m. (6 in.)	7.6 c. m. (3 in.)	Surface	Air.
May	1.18	1.95	0.91	0.43	0.35	0.24	1.00	1.45	1.79	3.79	8.12	4.91
June	1.10	2.10	0.90	0.40	0.30	0.20	1.00	1.50	2.00	4.50	10.50	5.50
July	1.29	2.10	1.06	0.48	0.38	0.26	1.00	1.46	1.85	4.08	8.08	5.00
August	1.50	2.60	1.20	0.50	0.40	0.30	1.00	1.33	1.66	4.00	8.66	5.00
September	1.30	3.00	1.10	0.50	0.30	0.30	1.00	1.00	1.66	3.66	10.00	4.33
October	1.30	2.20	0.90	0.30	0.30	0.20	1.00	1.50	1.50	4.50	11.00	6.50
Means, °C.	1.28	2.32	1.01	0.43	0.34	0.25	1.00	1.37	1.78	4.09	9.39	5.21
Means, 1882, °C.	1.12	1.66	0.97	0.46	0.31	0.17	1.00	1.82	2.70	5.70	9.76	6.59
Means, 1882, °F.	2.01	2.99	1.75	0.83	0.56	0.31						
Means, 1883, °F.	3.10	4.17	1.82	0.77	0.61	0.45						

We shall also see that the ratio of temperature between a depth of 7.6 c. m. (3 in.) and the surface was much greater for the past season, as follows :

	Surface.	7.6 c. m.
May	2.14	1.
June	2.33	1.
July	1.98	1.
August	2.17	1.
September	2.72	1.
October	2.44	1.
Means	2.29	1.
Means, 1882	1.72	1.

As in 1882, the hourly variations have been observed to reach a depth of somewhat over 30.4 c. m. (1 ft.), but from the fact that at this depth the hourly variations are frequently nothing, while at other times they are generally much less than one degree, rarely exceeding 0.5° (0.9° F.), it would appear that for the particular soil experimented upon, this is very nearly the limit of penetration for the hourly variation. Again, in 1882 it was found that the critical stratum, *i. e.*, when the variations of soil temperature equal those of the air, was at a depth of about 5.9 c. m. (2.3 in.) from the surface. The depth as determined from the figures for this year appears to be very near this, or 5.12 c. m. (2 in.) from the surface.

Subjoined is a table showing the figures for the isothermal curves for a depth of 30.4 c. m. (1 ft.) at 6 P. M., in comparison with the totals for 1882.

ISOTHERMAL CURVES FOR 30.4 C. M. (1 FT.) AT 6 P. M.

	Surface.		7.6 c. m. (3 in.)		15.2 c. m. (6 in.)		22.4 c. m. (9 in.)		30.4 c. m. (1 ft.)	
	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.
May	9	33	7	54	5	03	4	39	0	00
June	10	07	8	21	5	54	5	16	0	00
July	9	53	8	11	5	06	4	25	0	00
August	9	18	7	39	4	38	3	44	0	00
September	9	18	7	15	4	10	2	24	0	00
October	8	15	6	37	3	47	2	43	0	00
Means	9	24	7	39	4	46	3	52	0	00
Means, 1882.	9	51	7	39	5	38	4	42	0	00

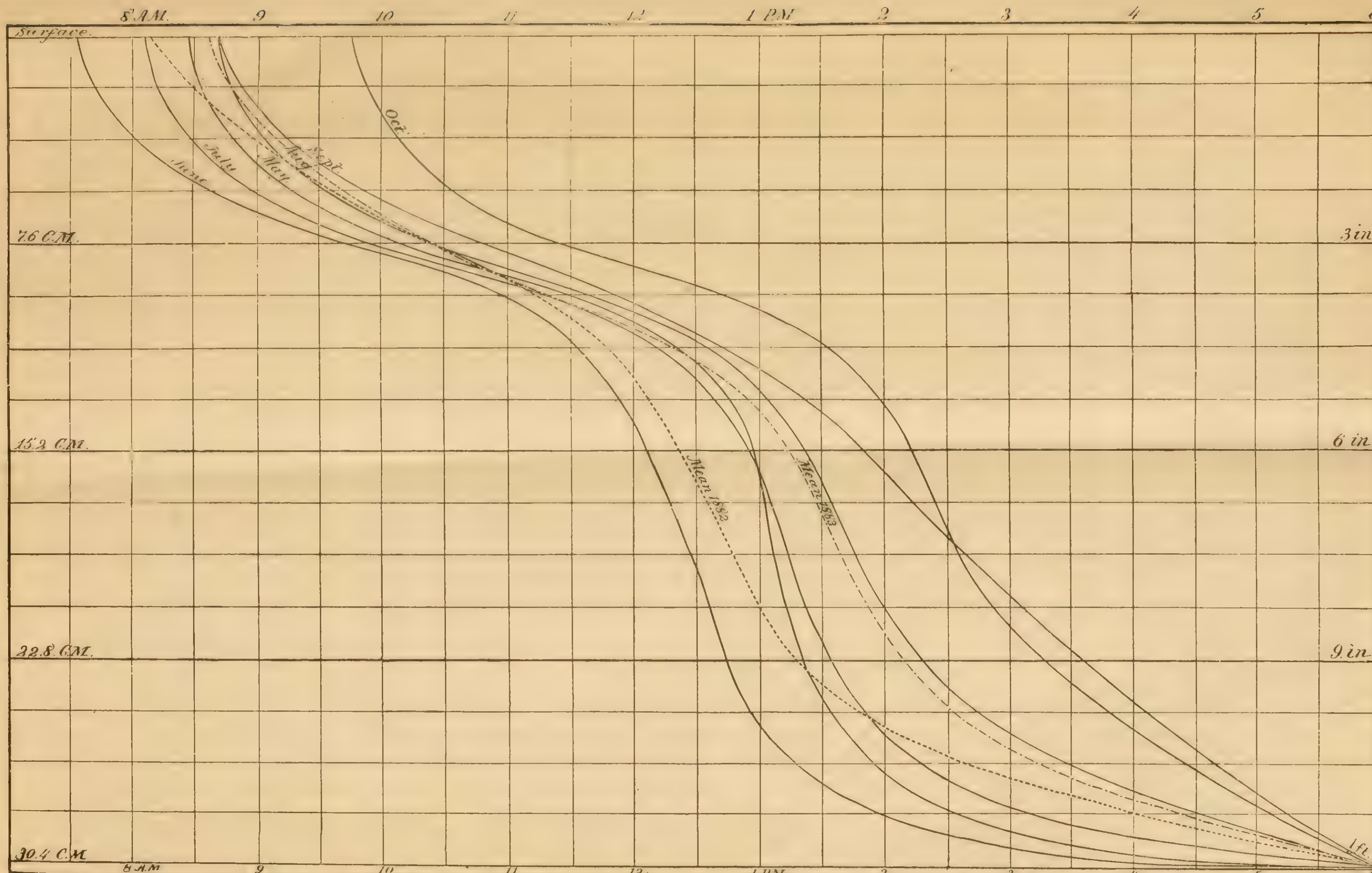
DAILY VARIATIONS.

The daily variations of temperature during the past season extended to a depth slightly greater than 2.4 m., and thus we will see a confirmation of the depth of penetration for 1882, which we found to be the same. We may consider for the present, therefore, that for the particular soil experimented upon, the penetration cannot extend much beyond 2.4 m. (7.8 ft.), probably not further than 2.5 m. (8.2 ft.) at the outside, since at the first depth the variations rarely exceed 0.15° (0.3° F.). This year the month of July was the one exhibiting the least daily variations, while August was the month in 1882. Comparing the variations for the two years, it will be seen that, as between different months, the means of the daily variations were more uniform than for the preceding year, and the same also holds true with regard to the changes from day to day. Comparing the means of the daily variations for the whole of each season, this will be still more apparent, as it will be seen from the following table, that the means for 1883 are in nearly all cases less than for 1882, and this we find, also, to be correlated to more general distribution of rain, and so to a greater degree of continuous humidity, with absence of extremes of drought and moisture.

MEAN DAILY VARIATIONS.

7 A. M. to 7 P. M.

	Air.	Surface.	7.6 c. m. (3 in.)	15.2 c. m. (6 in.)	22.8 c. m. (9 in.)	30.4 c. m. (1 ft.)	91.3 c. m. (3 ft.)	1.5 m. (5 ft.)	2.4 m. (8 ft.)
May	2. 6	2. 6	1. 8	1. 4	1. 3	0. 9	0. 2	0. 1	0.1
June	2. 3	2. 8	1. 5	0. 8	0. 6	0. 7	0. 5	0. 2	0.2
July	1. 2	1. 9	1. 2	0. 8	0. 8	0. 6	0. 1	0. 1	0.1
August	1. 9	2. 6	1. 5	0. 9	0. 8	0. 6	0. 1	0. 1	0.1
September	2. 3	2. 6	1. 5	1. 1	1. 0	0. 9	0. 2	0. 1	0.0
October	1. 8	2. 3	1. 5	1. 3	1. 4	1. 2	0. 3	0. 1	0.1
Means, ° C.	2.01	2.47	1.50	1.05	0.98	0.81	0.23	0.11	0.10
Means, 1882, ° C.	2.55	2.43	1.75	1.19	1.03	0.83	0.19	0.17	0.09
Means, 1883, ° F.	3.62	4.45	2.70	1.89	1.78	1.46	0.41	0.19	0.18
Means, 1882, ° F.	4.59	4.37	3.15	2.14	1.85	1.49	0.34	0.31	0.16



ISOTHERMAL CURVES FOR 30.4 C. M., AT 6 P.M

PENHALLOW, 1883.

MEAN DAILY TEMPERATURES. 1883.

MAY.

Deg. Cent.

Date.	Air.	Surface.	7.6 c. m.	15 2 c. m.	22.8 c. m.	30.4 c. m.	91.3 c. m.	1.5 m.	2.4 m.
2	14.6	17.0	12.4	9.8	9.6	8.6	6.7	5.8	5.9
3	18.7	20.2	15.6	12.4	12.3	9.8	7.0	6.0	5.9
4	16.3	18.8	15.8	13.5	13.5	11.9	7.5	6.0	6.0
5	10.8	11.7	11.6	11.3	11.9	11.1	8.0	6.1	6.0
7	15.3	14.4	11.8	10.6	10.9	10.4	8.5	6.7	6.2
8	20.5	21.8	17.0	13.6	13.6	11.1	8.7	6.9	6.1
9	15.9	18.4	15.7	13.7	13.9	12.5	8.9	7.0	6.2
10	15.6	18.4	15.4	12.8	12.9	11.9	9.2	7.1	6.3
11	16.7	17.9	15.9	14.3	14.5	13.1	9.5	7.3	6.3
12	15.0	18.7	15.2	12.3	11.6	12.0	9.8	7.5	6.5
14	10.9	14.2	12.5	11.1	11.5	10.9	9.9	7.9	6.7
15	15.6	17.3	14.3	12.1	12.3	11.2	10.0	8.1	6.8
16	15.7	18.7	15.9	14.1	13.8	12.7	10.0	8.1	6.9
17	14.9	18.8	14.9	12.6	12.9	11.9	10.2	8.2	7.0
18	19.8	23.0	16.9	13.9	13.8	12.7	10.2	8.0	7.1
19	20.0	23.4	18.4	14.5	14.5	13.3	10.4	8.6	7.2
21	17.1	19.8	17.7	16.1	16.0	15.3	11.0	8.8	7.4
22	14.0	15.1	14.0	14.2	14.0	13.8	11.3	9.0	7.6
23	15.3	17.4	16.2	14.9	14.9	14.2	11.4	9.1	7.7
24	17.9	20.4	16.9	14.7	14.8	13.8	11.5	9.5	7.7
25	23.5	24.6	18.6	15.7	15.8	14.4	11.6	9.7	7.7
26	25.0	25.8	19.9	17.2	17.2	16.4	11.9	9.8	8.0
28	20.3	22.7	20.3	17.9	17.8	16.9	12.6	10.0	8.0
29	19.6	20.8	18.2	16.9	17.1	16.5	13.0	10.1	8.0
31	21.2	22.6	19.4	17.5	17.5	16.4	13.0	10.6	8.2
Means.	17.2	19.3	16.0	13.9	13.9	12.9	10.1	7.1	6.5
Means for 1882.	13.9	15.9	13.7	11.7	10.8	10.4	8.5	7.6	7.1

MEAN DAILY TEMPERATURES. 1883.

JUNE.

Deg. Cent.

Date.	Air.	Surface.	7.6 c. m.	15.2 c. m.	22.8 c. m.	30.4 c. m.	91.3 c. m.	1.5 m.	2.4 m.
1	19.7	24.1	19.8	17.2	17.0	15.9	13.1	10.9	8.3
2	20.0	24.6	20.2	17.3	17.1	16.3	13.2	11.0	8.4
4	24.1	24.9	21.5	18.9	18.6	17.2	13.5	11.2	8.7
5	27.6	31.5	25.7	21.8	21.2	19.4	13.9	11.3	8.8
6	27.7	29.4	25.4	22.4	21.9	20.7	14.1	11.5	9.0
7	24.1	26.0	24.2	22.5	22.1	20.9	14.9	11.8	9.0
8	25.4	28.4	24.9	23.0	21.9	20.6	11.5	12.0	10.0
9	25.2	28.7	24.5	21.7	21.8	20.6	15.5	12.5	9.5
11	26.1	30.2	26.3	23.9	23.8	22.5	16.5	13.5	10.0
12	25.2	30.4	25.7	22.6	22.5	21.2	17.0	13.5	10.5
13	25.1	28.1	25.1	23.0	22.2	21.8	17.0	14.0	10.5
14	18.8	26.0	22.0	20.9	20.5	19.8	17.0	14.0	10.0
15	22.6	28.8	24.2	21.0	20.8	19.6	17.1	14.2	10.5
16	21.8	27.6	24.0	21.3	20.9	20.8	17.0	14.0	10.2
18	18.1	18.9	20.2	19.8	20.0	19.9	17.5	15.0	11.0
19	23.9	27.0	22.4	20.2	20.0	19.0	17.0	14.5	11.0
21	21.3	24.8	21.9	20.6	20.8	20.4	17.0	14.6	10.8
22	23.6	26.3	23.3	21.5	21.5	20.3	17.5	15.0	11.6
23	27.7	30.8	25.0	22.0	21.8	20.6	17.4	15.0	11.8
25	24.0	29.5	26.0	23.5	22.7	21.6	17.8	15.0	11.2
26	21.5	23.5	22.1	22.1	22.1	21.5	18.0	15.0	11.2
27	19.1	20.5	20.5	20.3	20.5	20.2	18.0	15.1	11.3
28	24.5	26.4	24.4	22.2	21.9	20.7	18.1	15.2	11.5
29	23.1	25.7	24.1	22.7	22.7	21.6	18.0	15.2	11.5
30	23.3	27.3	24.6	22.7	22.5	21.2	18.1	15.4	11.6
Means.	23.3	26.4	23.5	21.4	21.1	20.1	16.2	13.9	10.3
Means for 1882.	22.6	26.7	23.8	20.5	19.9	18.5	18.8	12.3	9.6

MEAN DAILY TEMPERATURES. 1883.

JULY.

Deg. Cent.

Date.	Air.	Surface.	7.6 c. m.	15.2 c. m.	22.8 c. m.	30.4 c. m.	91.3 c. m.	1.5 m.	2.4 m.
2	25.9	26.6	23.1	21.0	20.6	20.0	18.0	15.6	11.9
3	26.4	28.5	24.9	22.7	22.4	21.1	18.1	15.8	12.0
4	30.7	32.3	25.6	25.6	24.9	23.5	18.1	15.9	12.0
6	30.4	33.1	28.6	25.8	25.4	23.8	18.9	16.0	12.2
7	30.3	32.4	28.8	26.4	25.8	24.5	19.1	16.0	12.2
9	19.7	22.5	21.4	20.5	20.6	20.1	19.7	16.3	12.4
10	22.4	26.0	23.5	21.6	21.5	20.5	19.3	16.6	12.5
11	24.4	26.4	23.3	21.5	21.2	20.6	19.0	16.9	12.8
12	21.7	22.8	22.1	21.5	21.6	20.9	19.0	16.8	12.8
13	24.2	25.4	23.6	22.1	21.8	20.8	19.0	16.9	12.9
14	24.5	28.4	25.9	22.6	22.2	21.2	19.0	17.0	13.0
16	26.7	29.9	26.6	24.2	23.7	22.3	19.2	17.0	13.1
17	26.8	28.6	25.5	23.6	23.5	22.3	22.3	17.0	13.1
18	24.1	28.2	25.1	23.2	23.1	22.0	19.6	17.0	13.2
19	21.6	25.1	24.4	21.9	21.8	21.0	19.7	17.0	13.5
20	21.6	26.4	23.6	21.0	20.9	20.2	19.7	17.0	13.3
21	23.6	26.7	23.7	21.1	20.8	20.1	19.5	17.0	13.5
23	25.6	26.9	25.6	23.6	23.4	22.3	19.5	17.1	13.6
24	22.2	25.4	24.1	22.6	22.2	21.5	19.7	17.0	13.8
25	23.3	27.2	26.5	22.3	21.9	20.2	19.5	17.2	13.9
26	24.1	28.1	26.9	23.4	23.5	21.9	19.7	17.3	14.0
27	22.9	24.7	24.7	22.9	21.9	21.5	19.8	17.2	13.9
28	23.9	25.2	24.2	22.4	22.1	21.6	19.8	17.4	13.9
30	20.8	24.8	23.7	21.2	20.9	20.5	19.9	17.6	14.0
31	23.2	26.7	25.4	21.8	21.2	20.7	19.8	17.5	14.1
Means.	24.4	27.1	24.8	22.7	22.4	21.4	19.3	16.8	13.1
Means for 1882.	25.6	28.2	26.2	23.9	23.7	21.9	18.8	16.6	12.6

MEAN DAILY TEMPERATURES. 1883.

AUGUST.

Deg. Cent.

Date.	Air.	Surface.	7.6 c. m.	15.2 c. m.	22.8 c. m.	30.4 c. m.	61.3 c. m.	1.5 m.	2.4 m.
1	25.5	28.4	25.8	22.8	22.3	21.6	19.8	17.6	14.1
2	20.2	21.1	21.1	20.7	20.9	20.9	19.8	17.5	14.2
3	23.4	25.0	24.8	22.1	21.7	20.9	19.9	17.6	14.1
4	20.5	22.8	22.1	20.2	20.2	19.8	19.6	17.6	14.7
6	22.5	26.1	23.6	20.8	20.3	19.7	19.1	17.5	14.3
7	22.8	26.6	23.7	20.8	20.0	19.6	19.1	17.6	14.3
8	22.6	26.6	23.9	21.7	20.3	19.7	19.0	17.3	14.6
9	23.2	26.8	24.4	21.6	20.8	20.1	19.1	17.5	14.5
10	20.6	22.5	21.5	20.0	19.9	19.9	19.1	17.4	14.5
11	23.4	26.6	23.9	20.4	19.9	19.2	19.1	17.5	14.5
13	22.8	27.8	24.9	22.4	21.9	21.3	19.2	17.4	14.6
16	17.3	18.8	18.7	18.7	19.7	19.1	19.2	17.5	14.8
17	23.4	25.9	23.1	19.7	19.1	18.6	19.0	17.5	14.9
18	25.6	26.9	23.6	21.1	20.5	20.3	19.0	17.5	14.8
20	21.6	29.3	26.3	23.5	22.7	21.9	19.1	17.5	15.0
21	27.1	30.1	26.4	24.3	23.5	22.8	19.4	17.4	14.9
22	26.9	30.1	25.3	23.0	22.3	21.7	19.7	17.5	14.9
23	26.1	27.5	24.9	22.8	22.2	21.9	19.8	17.5	15.0
24	23.4	29.6	26.5	23.6	23.1	22.4	19.8	17.5	15.0
25	21.9	30.8	24.2	21.2	20.8	20.6	19.9	17.9	14.9
27	18.7	28.5	22.6	19.8	19.5	19.4	20.0	18.0	15.4
28	19.5	28.3	22.0	19.1	18.7	18.7	19.8	17.8	15.2
29	18.7	26.1	21.5	19.2	18.8	18.8	19.5	17.8	15.0
30	20.1	25.6	21.9	19.5	19.1	19.1	19.2	17.8	15.2
31	21.4	28.6	23.5	20.2	19.6	19.2	19.4	17.9	15.2
Means.	22.6	26.7	23.6	21.2	20.7	20.3	19.4	17.6	14.7
Means for 1882.	25.2	26.8	24.4	22.9	22.5	22.1	20.9	19.2	15.6

MEAN DAILY TEMPERATURES. 1883.

SEPTEMBER.

Deg. Cent.

Date.	Air.	Surface.	7.6 c. m.	15.2 c. m.	22.8 c m.	30.4 c. m.	91.3 c. m.	1.5 m.	2.4 m.
1	22.9	29.2	24.2	20.1	19.4	19.2	19.0	17.8	15.2
3	18.3	28.4	23.7	20.9	20.2	19.8	19.2	17.5	15.2
4	17.6	27.0	21.3	18.6	18.0	18.0	19.0	17.6	15.2
5	18.7	26.4	22.5	20.0	19.3	19.1	19.0	17.5	15.2
6	19.0	30.3	22.4	19.1	18.0	18.0	19.0	17.5	15.2
7	21.3	30.5	22.5	19.1	18.2	18.1	18.8	17.5	15.2
8	20.1	22.6	20.5	19.1	18.7	18.7	18.7	17.4	15.2
10	13.9	26.1	17.9	15.9	15.9	15.9	18.4	17.3	15.2
11	16.6	23.4	18.3	15.8	15.3	15.4	17.9	17.1	15.1
12	13.9	16.1	16.3	16.2	16.2	16.4	17.8	17.0	15.2
13	17.3	18.3	17.7	16.8	16.8	16.8	17.7	17.0	15.2
14	22.7	23.1	21.8	19.6	19.0	18.4	17.6	16.9	15.2
15	22.6	24.9	22.9	20.1	19.6	19.1	17.8	16.8	15.3
17	21.2	24.5	22.1	20.8	20.3	19.8	18.0	16.6	15.0
18	17.6	23.7	19.9	18.7	18.5	18.2	18.3	16.6	15.2
19	18.7	22.0	18.2	16.9	16.7	16.6	18.0	16.7	15.2
20	19.3	22.0	18.7	17.2	16.9	16.7	17.8	16.8	15.2
21	20.8	23.9	19.8	17.4	17.0	16.7	17.6	16.5	15.0
22	17.2	22.0	19.0	17.3	16.9	16.6	17.5	16.6	15.0
24	17.6	17.5	17.1	16.5	16.7	16.5	17.2	16.4	15.0
25	16.7	13.6	15.2	15.0	15.4	15.4	17.2	16.5	15.0
26	12.7	18.0	14.5	13.6	13.8	13.8	16.8	16.4	15.0
27	17.0	17.8	14.0	12.2	12.8	12.9	16.4	16.2	15.0
28	19.1	19.5	17.1	15.4	15.2	14.9	16.1	15.9	14.9
29	11.7	15.5	14.2	13.7	14.0	14.0	16.1	15.9	14.9
Means.	18.2	22.6	19.3	17.6	17.1	17.2	17.9	16.9	15.1
Means for 1882.	19.5	21.2	18.6	18.7	18.8	18.3	18.7	18.3	15.9

MEAN DAILY TEMPERATURES. 1883.

OCTOBER.

Deg. Cent.

Date.	Air.	Surface.	7.6 c. m.	15.2 c. m.	22.8 c. m.	30.4 c. m.	91.3 c. m.	1.5 m.	2.4 m.
1	10.1	15.1	13.7	13.5	13.6	13.4	15.6	15.4	14.8
2	13.8	12.8	12.3	11.6	12.0	12.2	15.3	15.4	14.8
3	14.1	14.8	13.3	12.4	12.5	12.5	15.0	15.2	14.7
4	8.7	11.6	9.9	10.1	10.6	10.9	14.8	15.0	14.9
5	8.5	13.2	9.8	9.0	9.4	9.6	14.2	14.7	14.7
6	8.4	10.3	8.7	8.0	8.4	8.9	13.8	14.5	14.7
8	12.8	16.7	12.9	11.2	11.2	11.1	13.5	14.0	14.6
9	14.5	15.9	13.4	12.2	12.3	12.1	13.4	14.0	14.6
10	19.2	21.0	14.9	12.7	12.6	12.2	14.7	14.0	14.5
11	18.5	20.8	15.8	13.7	13.5	13.1	13.8	13.8	14.3
12	15.7	16.4	15.2	14.0	14.1	13.9	13.8	13.7	14.2
13	21.1	22.6	19.8	17.2	16.5	15.8	13.8	13.7	14.2
15	7.7	12.7	11.2	12.9	13.5	13.8	14.8	13.8	13.9
16	4.7	11.8	8.1	8.6	9.2	9.7	14.6	14.0	13.9
17	5.1	10.0	6.8	7.0	7.6	8.1	13.8	13.9	13.8
19	14.9	14.1	12.1	11.2	10.3	10.2	12.8	13.4	13.7
20	14.9	15.1	14.7	13.4	13.2	12.7	12.8	13.3	13.7
22	7.3	10.5	9.1	8.5	8.9	8.9	12.7	13.0	13.7
23	6.4	7.8	7.9	8.3	8.4	9.0	12.4	13.0	13.7
24	5.7	6.1	6.6	6.9	7.3	7.8	12.2	12.7	13.5
25	6.5	8.7	7.5	6.7	7.0	7.4	11.7	12.5	13.4
26	6.2	7.3	7.3	7.2	7.5	7.8	11.5	12.3	13.3
27	8.5	9.5	9.1	8.2	8.3	8.3	11.4	12.3	13.3
29	15.4	13.8	12.8	10.7	10.5	10.2	11.3	12.0	13.3
30	15.0	12.3	12.7	11.9	12.0	11.7	11.5	11.8	13.2
31	12.1	10.7	9.8	9.6	9.9	10.0	11.6	11.7	13.0
Means.	11.4	13.1	11.4	10.6	10.8	10.8	13.3	13.6	14.4
Means for 1882.	14.3	14.9	14.1	14.2	14.4	14.2	15.2	15.0	14.8

The wave periods, both maximum and minimum, for 1883, are found to have been somewhat shorter, and so more frequent than for 1882. The following tabular view will give all the necessary details without further explanation.

MAXIMUM WAVE PERIODS.

May,	12,	10,	8, +June.		
June,	May+3,=11,	11,	13,	3,+July.	
July,	June+8,=11,	10,	11,	1,+Aug.	
August,	July +7,= 8,	9,	11,	4,+Sept.	
September,	Aug.+3,= 7,	6,	9,	8,	4,+Oct.
October,	Sept.+5,= 9,	11,	15,+Nov.		

MINIMUM WAVE PERIODS.

May,	5,	3,	2,	2,	3,	5,	6,	3,	1,+June.
June,	May +3,= 4,	4,	3,	4,	3,	6,	3.		
July,	3,	4,	4,	7,	5,	5,	2,+Aug.		
August,	July +1,= 3,	3,	4,	4, ——	5,	6,	4.		
September,	3,	2,	4,	6,	3,	3,	5,	2,	2,+Oct.
October,	Sept.+1, = 3,	4,	4,	7,	5,	3,	6,	1,+Nov.	

Comparing the results for the two years, the mean length of the maximum and minimum wave periods in days, appears to be about as follows:

Maximum 11.4.

Minimum, 4.7.

or the two periods stand to one another in the ratio of 1:2.42.

In our last report, the time of occurrence of the daily maximum of soil temperature was not discussed, and these data are therefore introduced in comparison for the two years. It will be observed that for most of the positions taken, there is but little difference in the mean time of occurrence for the entire season, but comparing the same months with each other, it will be seen that there are important variations, and doubtless our further studies will show that this bears a more or less important relation to the condition of soil humidity.

MEAN TIME OF DAILY MAXIMA.

		Air.	Surface.	7.6 c. m. (3 in.)	15.2 c. m. (6 in.)	22.8 c. m. (9 in.)	30.4 c. m. (1 ft.)
1882	May	3.00 P. M.	1.48 P. M.	2.54 P. M.	4.54 P. M.	6.30 P. M.	6.30 P. M.
	June	3.18 "	1.48 "	3.24 "	5.30 "	6.30 "	7.54 "
	July	3.12 "	2.00 "	2.54 "	4.48 "	5.36 "	6.12 "
	August	2.48 "	1.18 "	3.12 "	5.24 "	6.18 "	7.36 "
	September	2.18 "	1.12 "	2.36 "	3.54 "	5.18 "	5.24 "
	October	2.24 "	1.30 "	2.48 "	4.30 "	5.06 "	7.30 "
Means		2.50 "	1.36 "	2.58 "	4.50 "	5.53 "	6.51 "
1883	May	2.18 P. M.	1.30 P. M.	3.36 P. M.	5.18 P. M.	5.54 P. M.	6.42 P. M.
	June	2.12 "	1.24 "	2.48 "	5.06 "	5.36 "	6.12 "
	July	3.06 "	1.36 "	2.48 "	4.24 "	5.24 "	6.30 "
	August	3.12 "	2.12 "	3.24 "	5.18 "	6.00 "	6.36 "
	September	2.36 "	1.06 "	2.48 "	4.36 "	5.48 "	6.12 "
	October	2.24 "	1.00 "	2.30 "	4.30 "	5.30 "	6.30 "
Means		2.36 "	1.24 "	2.54 "	4.54 "	5.42 "	6.24 "

MONTHLY VARIATIONS.

The monthly variations for 1883 do not show so great extremes as for the previous year, the greatest variation for the year being 9.5° (17.1° F.) for 1882. In the latter year, the most marked differences were found between May and June, but for the former, the greatest differences have been found between September and October. The generally more uniform rate of change corresponds well with the more general distribution of rain throughout the season. Comparing the means of variations for the entire season, it will be observed that there is a close correspondence, the greatest difference being only 1.1° (1.1° F.) while the others run from this down to only 0.1°. (0.18° F.) The following table will make these relations sufficiently obvious without further explanation:

MONTHLY VARIATIONS OF TEMPERATURE.

	Air.	Surface.	7.6 c. m. (3 in.)	15.2 c. m. (6 in.)	22.8 c. m. (9 in.)	30.4 c. m. (1 ft.)	91.3 c. m. (3 ft.)	1.5 m. (5 ft.)	2.4 m. (8 ft.)
May	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
June	6.1	7.1	7.5	7.5	7.2	7.2	6.1	6.8	3.8
July	1.1	0.7	1.3	1.3	1.3	1.3	3.1	2.9	2.8
August	1.8	0.4	1.2	1.5	1.7	1.1	0.1	0.8	1.6
September	4.4	4.1	4.3	3.6	3.6	3.1	1.5	0.7	0.4
October	6.8	9.5	7.9	7.0	6.3	6.4	4.6	3.3	0.7
Means	4.2	4.4	4.4	4.2	4.2	3.8	3.1	2.9	1.9
Means, 1882	4.5	5.5	5.1	4.4	4.4	3.9	3.6	3.1	2.0
Means 1882, °F	8.1	9.9	9.2	7.9	7.9	7.0	6.5	5.6	3.6
Means, 1883, °F	7.6	7.9	7.9	7.6	7.6	6.8	5.6	5.2	3.4

MEAN MONTHLY TEMPERATURES.

	Air.	Surface.	7.6 c. m. (3 in.)	15.2 c. m. (6 in.)	22.8 c. m. (9 in.)	30.4 c. m. (1 ft.)	91.3 c. m. (3 ft.)	1.5 m. (5 ft.)	2.4 m. (8 ft.)
May	17.2	19.3	16.0	13.9	13.9	12.9	10.1	7.1	6.5
June	23.3	26.4	23.5	21.4	21.1	20.1	16.2	13.9	10.3
July	24.4	27.1	24.8	22.7	22.4	21.4	19.3	16.8	13.1
August	22.6	26.7	23.6	21.2	20.7	20.3	19.4	17.6	14.7
September	18.2	22.6	19.3	17.6	17.1	17.2	17.9	16.9	15.1
October	11.4	13.1	11.4	10.6	10.8	10.8	13.3	13.6	14.4
Means	19.5	22.5	19.8	17.9	17.7	17.1	16.0	14.3	12.4
Means, 1882	19.9	22.3	20.1	18.6	18.4	17.6	17.1	14.8	12.6
Means, 1882, °F	67.8	72.5	68.2	65.5	65.1	63.7	62.8	58.6	54.7
Means, 1883, °F	67.1	72.5	67.6	64.2	63.9	62.8	60.8	57.7	54.3

ABSOLUTE MAXIMUM AND MINIMUM TEMPERATURES FOR EACH MONTH.

	Maximum.	Minimum.
May	26th	1st
June	11th	1st
July	7th	9th
August	21st	16th
September	1st	29th
October	13th	24th

ABSOLUTE MAXIMUM AND MINIMUM TEMPERATURE FOR SIX MONTHS.

	Maximum.	Minimum.
30.4 c. m. (1 ft.) or less.............	July 7th	Oct. 24th
91.3 c. m. to 2.4 m. (3 to 8 ft.),.....	Aug. 27th	May 2d

The following table of soil depths for equivalents of air temperatures, is given without comment, in comparison with the means for the previous year.

SOIL DEPTHS OF EQUIVALENTS FOR AIR TEMPERATURES.

	MEAN TEMPERATURE OF AIR.		DEPTH.	
	°C.	°F.	Centimetres.	Inches.
May.....................	17.2	62.9	4. 9 c. m.	1.93
June.....................	23.3	73.9	9.12 "	3.58
July.....................	24.4	75.9	9. 1 "	3.58
August.....................	22.6	72.7	10. 8 "	4.25
September.....................	18.2	64.8	12. 5 "	4.93
October.....................	11.4	52.5	7. 6 "	3.00
Means.....................	19.5	67.1	9.00 "	3.54
Means, 1882..............	19.9	67.8	12. 5 "	4.93

ELECTRICAL THERMOMETER.

In considering the record of soil temperatures as determined by the electrical thermometer, it is first necessary to describe the general character of the soil and its formation. The thermo-couples were placed in position March 10th, 1883. The soil was removed carefully, and the different layers kept as distinct as possible. When the tube containing the couples was in position, the earth was replaced as nearly in its original position as possible, and several weeks were allowed to elapse that it might settle thoroughly before regular determinations of temperature were made. At the time of excavation, the formation was found to be as follows :

Surface.

Alluvium . . . . 32.9 c. m. + 5.0 c. m. = 33.4 c. m. (13.1 in.)
Sandy loam . . . 48.1 c. m. or (18.9 in.)
Coarse gravel . . . 10.37. d. m. or (3 ft. 4.8 in.)
Quicksand to a depth of more than three meters (9 ft. 10 in.) from the surface.

The alluvium, originally 32.9 c. m (12.9 in.) in thickness, was afterwards increased by the addition of 5 c. m. (1.9 in.) of soil to compensate for an elevation

of the tube to that extent, doubtless as a result of the action of the quicksand upon the lower extremity.

With regard to the source of material forming these strata, we have to consider that it was largely derived from the adjacent slopes, at the foot of which the couples are located. We thus see that Gneiss, Potsdam sandstone and Hudson River slate are the principal components, and we would thus assign a chemical composition which would correspond in general with that of these rocks.

The stratification as given above, shows us that, at a depth of 48.1 c. m. (18.9 in.) from the general surface, we encounter a stratum which serves as an open drain for the water of percolation, and also serves to admit the water from neighboring streams.

So far as color is concerned, the second stratum of sandy loam would correspond well with the second stratum of soil where the mercurial thermometers are located. In the surface strata, however, there is a marked difference both in color and mechanical condition, and as the color of the surface layers exerts an important influence upon its own temperature and that of subjacent layers, it is important to consider these differences in order that comparisons of temperature for the two localities may be made with some degree of accuracy.

We find the surface stratum of soil at the position of the mercurial thermometers described as "Gravel with some clay, 30.5 c. m." (1 ft.). *We also find the color to be light, yellowish brown. At the electrical thermometers, the surface stratum of alluvium is dark brown, or brownish black when moist, this to be taken as the normal color and condition of the stratum as a whole, though at the immediate surface, where exposed to the action of sun and wind, the color for a depth of one or two centimeters (0.4 to 0.8 in) becomes gray. It is thus apparent (1) that the alluvium has a much stronger tendency as a whole to absorb an increased amount of heat, and (2) that the layer at the immediate surface, while having a greater absorptive power than the corresponding layer at the position of the mercurial thermometers, is variable in its relation to absorption and radiation according to variation in color. We must further bear in mind that the very conditions of moisture which increase the depth of color, and so the tendency to absorb and radiate heat, also tend to counteract the absorptive power developed in this way.

If we further inquire into the various strata penetrated by the thermocouples in use, we shall find the relation to be as follows:

		Couples.
Alluvium . .	38. c. m. (1 ft. 2.9 in.)	7.6; 22.8; 30.4. c. m. (3 in., 9 in., 1 ft.)
Sandy loam .	48.1 c. m. (1 ft. 7 in.)	0.
Coarse gravel .	10.37 d. m. (3 ft. 4.9 in.)	60.8 c. m. (2 ft.)
Quicksand .		0.

There were only four couples used the past year, taken at the depths shown

*H. F. Series I. No. 2, p. 20.

above, so it will be seen that most of them penetrated the alluvium alone, and so to this stratum the record for this year chiefly relates.

In order to more exactly determine the influence of humidity upon the soil temperature as affected by variations in the water table, an arrangement was devised, by means of which the rise and fall of the latter below the surface of the soil, as expressed in decimeters, could be determined at pleasure. For this purpose, a well was formed of four-inch glazed tile, near the thermo-couples. A large float in the well was directly connected through a light chain which passed over a wheel, with a lead bob which moved on a vertical scale graduated to 0.5 c. m. (0.2 in.). By careful measurements in the first place, the scale was exactly placed so that the direct readings gave the true distance from the surface of the soil to the water table. Readings were taken daily at 2 o'clock, P. M., and the record will be found under its proper heading in the same tables with the mean daily soil temperatures.

At a distance of but little over fifty feet from the thermo-couples, there is a natural brook, and owing to the open character of the sub-soil, it will be obvious that the water table, as determined at the float, is controlled by and dependent upon variations in volume of water in the brook. But this renders the position all the more valuable for determining the relation of humidity to soil temperatures, and it was this consideration among others, which determined a selection of the position. The variations of the record as shown, may thus be taken as representing the rise and fall of the stream as influenced by rainfall. It will be observed that on the 30th of September, the water table fell from 8.9 d. m. (2 ft. 11 in.) to 10 4 d. m. (3 ft. 4.9 in.), this great depression continuing until the 23d of October, when it again rose to 7.5 d. m. (2 ft. 5.6 in.). This extreme variation was due to the fact that, on the former date the pond near by was drawn off, thus lowering the stream, and that on the latter date the flood-gate was again closed, bringing the water up to its former level.

With regard to the changes indicated by these figures, it would be foreign to our present purpose to consider them otherwise than in their direct relation to variations of temperature. This relation, however, will for the present, be sufficiently shown by the tables given, as the figures are so arranged as to permit easy comparison, and it is only necessary at this time to indicate what we may look for as the result of the water in the soil.

Whenever water is present, it exerts a strong equalizing influence upon extremes of temperature, modifying both heat and cold, and preventing sudden changes of temperature. We might therefore look for a reduction in the hourly variations, and also in the daily and monthly variations ; the thermal waves would probably show greater regularity and less amplitude ; the diminution of variation would decrease, and uniformity of temperature increase as the water table was approached. But other important factors here appear. As we come nearer the surface we shall meet with layers where there is a constant tendency to the formation and condensation of vapor within the soil, and this will tend to complicate matters to a degree which must not be neglected in our considerations. Again, in comparing the results thus obtained with those determined in a less humid soil, we cannot make direct and exact comparisons, as we must further take into consideration not only the mechanical condition of the soil, but

its color, both when dry and moist, and as from the previous description of the soil in this locality, we find it to be black when moist, it presents a striking contrast with the reddish brown soil found where the mercurial thermometers are employed. As we stated last year, the color of the surface soil exerts an important influence upon the temperature of all the strata beneath, so that, as in this soil, when the dry color is gray and the moist color black, we have elements of further complication. All these considerations demonstrate the necessity of careful experiments in the laboratory, which will render it possible to determine the exact influence of these physical conditions upon temperature, by working upon the basis of known and exactly determined laws. Until such experiments are undertaken and carefully executed, it is not proper for us to do more than present the record thus far obtained, with such comments as appear justified by the present stage of the work. Also, in view of what has already been said with regard to the working of the instrument, the record will be given wholly without comment, simply placing the facts upon record at this time and in this connection for such comparisons as may seem desirable, and for future verification. All degrees of temperature are given in centigrade, and all the records of the water table are in decimeters and decimals unless otherwise specified.

MEAN HOURLY VARIATIONS OF TEMPERATURE.

7 A. M. to 7 P. M.

	Air.	7.6 c. m. (3 in.)	22.8 c. m. (9 in.)	30.4 c. m. (1 ft.)	60.8 c. m. (2 ft.)
May	1.18	1.00	0.63	0.57	0.53
June	1.10	1.00	0.80	0.30	0.20
July	1.29	1.22	1.09	0.95	0.97
August	1.50	0.9	0.6	0.6	0.50
September	1.30	0.7	0.4	0.3	0.10
October	1.30	0.7	0.4	0.2	0.10
Means, °C	1.28	0.92	0.65	0.49	0.40
Means, °F	2.46	1.66	1.17	0.88	0.72

MEAN DAILY VARIATIONS.

	Air.	7.6 c. m. (3 in.)	22.8 c. m. (9 in.)	30.4 c. m. (1 ft.)	60.8 c. m. (2 ft.)
May	2.6	1.6	1.1	0.9	0.8
June	2.3	1.3	1.0	0.8	0.6
July	1.2	1.1	0.9	0.7	0.9
August	1.9	1.2	0.7	1.4	0.6
September	2.3	1.1	1.3	1.0	0.8
October	1.8	1.3	1.0	1.0	0.5
Means, °C	2.01	1.27	1.00	0.80	0.7
Means, °F	3.62	2.29	1.80	1.44	1.30

MEAN DAILY TEMPERATURES.

Date.	MAY. Air.	7.6 c. m.	22.8 c. m.	30.4 c. m.	60.8 c. m.	Water Table.	JUNE. Air.	7.6 c. m	22.8 c. m.	30.4 c. m.	60.8 c. m.	Water Table.
1	....	....	....	....	....	6.46	19.7	17.5	15.8	15.3	13.8	7.50
2	14.6	13.3	10.3	9.6	8.1	6.60	20.0	18.6	17.6	15.6	14.1	7.60
3	18.7	12.7	12.5	11.3	12.7	6.50	....	....	....	....	....	7.60
4	16.3	16.4	13.8	13.2	10.4	6.70	24.1	20.2	17.3	17.1	15.1	7.50
5	10.8	12.4	11.9	11.7	10.9	6.80	27.6	24.7	20.0	18.3	15.3	7.60
6	....	....	..	....	....	6.15	27.7	24.5	21.7	20.6	17.4	7.70
7	15.3	12.8	11.6	11.1	10.4	6.45	24.1	22.5	21.1	20.4	16.9	7.50
8	20.5	16.5	13.9	12.7	10.7	6.80	25.4	22.1	19.7	18.8	16.4	7.52
9	15.9	14.8	13.2	12.5	10.8	6.80	25.2	21.5	20.5	19.5	17.6	7.72
10	15.6	15.0	12.8	12.2	10.4	7.00	....	....	....	....	....	7.81
11	16.7	16.1	14.7	14.1	12.4	6.80	26.1	22.3	21.1	20.0	17.3	7.87
12	15.0	14.6	13.3	12.7	11.7	6.95	25.2	21.9	20.2	18.6	17.2	7.95
13	....	....	....	....	....	7.10	25.1	21.8	21.3	19.0	18.0	7.95
14	10.9	12.0	11.4	11.4	11.2	7.20	18.8	19.2	18.7	18.3	17.3	8.00
15	15.6	14.0	13.1	12.2	11.8	6.74	22.6	20.1	18.1	17.2	16.6	8.00
16	15.7	15.3	13.9	13.3	11.9	7.00	21.8	19.3	18.0	17.8	16.2	8.05
17	14.9	14.9	12.9	12.6	11.8	7.20	....	....	....	....	....	8.00
18	19.8	17.3	14.9	13.8	12.2	7.30	18.1	19.4	19.1	18.6	17.9	7.55
19	20.0	17.6	14.5	13.3	12.0	7.40	23.9	20.1	18.7	18.0	17.1	7.52
20	....	....	....	....	....	7.42	....	....	....	....	....	7.50
21	17.1	17.7	15.6	15.0	13.0	7.45	21.3	20.7	19.8	18.9	17.6	7.82
22	14.0	14.4	14.3	14.1	13.8	6.25	23.6	21.8	19.6	18.6	17.1	7.98
23	15.3	15.7	14.5	14.4	13.5	6.50	27.7	22.3	20.3	17.9	17.4	8.05
24	17.9	16.3	14.2	13.8	12.6	6.95	....	....	....	....	....	8.10
25	23.5	19.0	15.7	14.2	13.0	7.10	24.0	24.8	20.7	19.7	17.8	8.20
26	25.0	20.7	17.4	17.7	13.5	7.20	21.5	21.4	20.5	20.3	18.6	8.20
27	....	....	....	....	....	7.30	19.1	19.6	18.8	19.6	18.3	8.10
28	20.3	19.3	17.0	16.4	14.4	7.40	24.5	22.5	20.6	19.8	17.6	6.80
29	19.6	18.6	17.2	16.9	15.0	7.45	23.1	21.8	20.2	20.2	18.4	7.50
30	....	....	....	....	....	7.51	23.3	21.4	20.1	19.3	17.9	7.20
31	21.2	18.8	16.9	16.5	14.6	7.48	....	....	....	....	....	....
Means.	17.2	15.4	14.1	13.4	12.1	6.96	23.3	21.3	19.6	18.7	17.0	7.74

MEAN DAILY TEMPERATURES.

	JULY.						AUGUST.					
Date.	Air.	7.6 c. m.	22.8 c. m.	30.4 c. m.	60.8 c. m.	Water Table.	Air.	7.6 c. m.	22.8 c. m.	30.4 c. m.	60.8 c. m.	Water Table.
1	....	....	....	....	....	7.60	25.5	24.2	21.2	20.6	18.2	8.30
2	25.9	21.9	19.4	19.3	17.6	7.85	20.2	20.8	20.5	20.5	20.2	7.30
3	26.4	22.8	20.5	20.0	17.9	8.00	23.4	23.2	21.2	20.6	19.3	7.90
4	30.7	25.3	22.7	21.2	18.5	8.10	20.5	21.8	20.3	19.9	18.8	8.20
5	....	....	....	....	....	8.00	....	....	....	....	....	8.30
6	30.1	26.9	23.6	22.6	19.9	7.90	22.5	21.5	20.1	19.1	17.9	8.40
7	30.3	29.9	24.0	22.6	20.1	8.10	22.8	19.1	17.4	16.9	15.5	8.50
8	....	....	....	....	....	7.50	22.6	18.9	17.5	16.6	16.2	8.50
9	19.7	20.5	19.2	18.8	17.8	7.40	23.2	19.7	17.1	16.7	16.3	8.45
10	22.4	21.8	19.9	19.3	18.6	7.70	20.6	18.2	17.4	17.2	16.9	8.45
11	24.4	22.6	21.5	20.4	17.8	7.70	23.4	19.3	18.2	17.4	16.4	8.50
12	21.7	21.1	20.9	19.9	19.1	7.70	....	....	....	....	....	....
13	24.2	23.0	21.2	20.5	18.9	7.35	22.8	19.1	17.7	17.7	15.4	8.55
14	24.5	23.7	20.7	20.7	17.8	7.70	....	....	....	....	....	8.41
15	....	....	....	....	....	7.80	....	....	....	....	....	8.50
16	26.7	24.9	21.6	20.8	18.1	7.10	17.3	16.7	16.6	16.5	16.9	8.50
17	26.8	25.3	23.1	21.6	19.3	7.70	23.4	18.3	16.7	16.4	16.1	8.50
18	24.1	23.6	20.9	20.2	17.4	7.85	25.6	20.1	18.1	16.8	15.9	8.50
19	21.6	22.6	20.3	19.9	17.3	8.00	....	....	....	....	....	8.40
20	21.6	22.4	20.7	20.1	18.5	8.05	27.6	21.8	19.9	18.7	16.9	8.25
21	23.6	24.3	21.9	21.3	20.6	8.10	27.1	21.1	19.4	18.5	16.4	8.10
22	....	....	....	....	....	8.10	26.9	21.4	18.3	17.7	16.4	8.30
23	25.6	23.8	21.6	21.1	17.9	8.10	26.1	....	....	....	....	8.50
24	22.2	22.7	21.1	20.1	18.6	8.10	23.4	21.4	19.2	17.3	15.6	8.45
25	23.3	22.2	19.9	19.1	17.5	8.25	21.9	19.7	18.8	17.3	16.9	8.50
26	24.1	22.8	20.8	20.0	18.4	8.30	....	....	....	....	....	8.50
27	22.9	22.7	20.9	20.7	18.1	8.30	18.7	19.5	17.7	16.5	16.6	8.60
28	23.9	23.2	21.9	20.8	19.2	8.22	19.5	19.7	16.9	16.8	17.1	8.80
29	....	....	....	....	....	....	18.7	19.4	18.1	17.6	17.2	8.80
30	20.8	21.7	19.8	20.2	18.4	8.20	20.1	19.3	17.8	17.3	17.2	8.90
31	23.2	22.8	20.8	19.8	17.7	8.30	21.4	20.1	18.0	17.2	16.9	8.90
Means.	24.4	23.4	21.1	20.8	18.4	7.89	22.6	20.2	18.5	17.8	17.0	8.40

MEAN DAILY TEMPERATURES.

Date.	September. Air.	7.6 c. m.	22.8 c. m.	30.4 c. m.	60.8 c. m.	Water Table.	October. Air.	7.6 c. m.	22.8 c. m.	30.4 c. m.	60.8 c. m.	Water Table.
1	22.9	20.2	18.6	17.8	17.2	8.8	10.1	12.5	13.4	13.5	13.3	10.6
2	....	....	....	....	....	8.9	13.8	11.6	11.3	11.8	13.3	10.2
3	18.3	18.2	16.7	16.2	16.1	9.0	14.1	12.5	12.7	12.0	12.9	10.3
4	17.6	17.4	16.4	16.1	17.1	8.8	8.7	9.8	10.3	10.3	13.3	10.9
5	18.7	19.7	18.6	18.1	17.9	8.7	8.5	9.3	8.9	9.2	12.4	10.9
6	19.0	17.4	16.1	15.9	15.8	8.7	8.4	7.9	8.8	9.2	11.4	10.9
7	21.3	20.2	17.1	16.7	17.1	8.8	....	....	....	....	....	10.9
8	20.1	18.1	16.6	16.2	16.5	8.7	12.8	12.6	11.1	10.4	11.2	10.9
9	....	....	....	....	....	8.7	14.5	11.3	11.0	11.0	11.5	10.9
10	13.9	14.1	13.7	13.7	15.6	8.7	19.2	13.8	11.9	11.0	11.2	11.0
11	16.6	15.1	13.3	13.4	15.8	8.7	18.5	14.2	12.5	11.8	11.6	11.0
12	13.9	14.2	13.9	14.0	14.9	8.5	15.7	13.9	13.1	12.6	12.1	11.1
13	17.3	16.6	15.7	15.1	15.3	8.1	21.1	....	....	....	....	11.0
14	22.7	20.7	18.4	17.4	16.0	8.2	....	....	....	....	....	11.1
15	22.6	21.1	19.3	18.2	17.6	8.3	7.7	10.7	11.3	12.5	13.8	11.2
16	....	....	....	....	....	8.3	4.7	10.1	9.5	7.8	12.4	11.4
17	21.2	21.7	20.4	18.8	18.0	8.4	5.1	7.2	7.7	8.2	12.7	11.3
18	17.6	18.7	17.5	17.5	16.5	8.4	....	....	....	....	....	....
19	18.7	17.3	17.0	15.6	15.7	8.5	14.9	11.0	9.8	9.3	10.2	11.5
20	19.3	18.0	16.7	15.6	16.1	8.5	14.9	13.4	10.7	11.4	10.7	11.1
21	20.8	18.2	16.1	15.3	15.3	8.5	....	....	....	....	....	11.5
22	17.2	17.5	16.2	15.3	15.9	8.5	7.3	8.6	9.3	8.7	11.0	11.3
23	....	....	....	....	....	8.9	6.4	8.6	9.5	9.3	11.5	11.4
24	17.6	14.9	14.9	14.7	15.0	8.6	5.7	7.0	7.6	8.7	10.8	7.5
25	16.7	15.1	14.6	14.2	14.7	8.3	6.5	8.5	7.9	7.9	10.1	8.2
26	12.7	13.1	13.2	13.5	15.0	8.5	6.2	7.7	8.0	8.5	10.6	8.3
27	17.0	13.2	11.7	11.7	13.9	8.6	8.5	8.9	8.6	8.6	10.1	8.4
28	19.1	16.1	14.8	14.2	14.1	8.6	....	....	....	....	....	8.4
29	11.7	12.9	12.9	13.0	14.6	8.6	15.4	12.7	11.3	11.1	10.7	6.9
30	....	....	....	....	....	10.4	15.0	....	....	....	....	6.5
31	....	....	....	....	....	....	12.1	9.7	10.2	10.5	10.4	7.4
Means.	18.2	16.4	16.0	15.5	15.9	8.67	11.4	10.6	10.3	10.12	11.6	10.1

MINIMUM WAVE PERIODS.

In Days.

May,	5, 3, 4, 4, 5, 5, 3, 1, + June.
June,	May, + 3,=4, 5, 3, 3, 4, 4, 5, 3.
July,	4, 4, 3, 7, 5, 5, 2, + Aug.
August,	July, + 2,=4, 6, 3, —— 5, 4, 4, 2, + Sept.
September,	Aug. + 3,=5, 2, 5, 8, 8, 4.
October,	5, 9, 4, 7, 8, 7.

MAXIMUM WAVE PERIODS.

May,	12, 10, 8, + June.
June,	May, + 3,=11, 11, 13, 3, + July.
July,	June, + 8,=11, 10, 11, 1, + Aug.
August,	July, + 7,= 8, 9, 11, 4, + Sept.
September,	Aug. + 3,= 7, 7, 16, 4, + Oct.
October,	Sept. + 5,= 9, 11, 8, 7, + Nov.

MONTHLY VARIATIONS OF TEMPERATURE.

	Air.	7.6 c. m. (3 in.)	2.28 c. m. (9 in.)	(1 ft.) 30.4 c. m.	60.8 c. m. (2 ft.)
May	0.0	0.0	0.0	0.0	0.0
June	6.1	5.9	5.5	5.3	4.9
July	1.1	2.1	1.5	2.1	1.4
August	1.8	3.2	2.6	3.0	1.4
September	4.4	3.8	2.5	2.3	1.1
October	6.8	5.8	5.7	5.3	4.3
Means, °C	4.2	4.2	3.6	3.6	2.6
Means, °F	7.6	7.6	6.5	6.5	4.7

MEAN MONTHLY TEMPERATURES.

	Air.	7.6 c. m. (3 in.)	22.8 c. m. (9 in.)	30.4 c. m. (1 ft.)	60.8 c. m. (2 ft.)
May	17.2	15.4	14.1	13.4	12.1
June	23.3	21.3	19.6	18.7	17.0
July	24.4	23.4	21.1	20.8	18.4
August	22.6	20.2	18.5	17.8	17.0
September	18.2	16.4	16.0	15.5	15.9
October	11.4	10.6	10.3	10.2	11.6
Means, °C	19.5	17.9	16.6	16.1	15.3
Means, °F	67.5	64.2	61.9	60.9	59.5

ABSOLUTE MAXIMUM AND MINIMUM TEMPERATURE FOR EACH MONTH.

	Maximum.	Minimum.
May	26th	1st
June	6th	1st
July	7th	9th
August	1st	16th
September	17th	27th
October	1st	24th

Table of Comparative Temperatures.

Centigrade to Fahrenheit.

o CENT.	o FAHR.	o CENT.	o FAHR.	o CENT.	o FAHR.
100.00	212.00	58.00	136.40	16.00	60.80
99.00	210.20	57.00	134.60	15.00	59.00
98.00	208.40	56.00	132.80	14.00	57.20
97.00	206.60	55.00	131.00	13.00	55.40
96.00	204.80	54.00	129.20	12.00	53.60
95.00	203.00	53.00	127.40	11.00	51.80
94.00	201.20	52.00	125.60	10.00	50.00
93.00	199.40	51.00	123.80	9.00	48.20
92.00	197.60	50.00	122.00	8.00	46.40
91.00	195.80	49.00	120.20	7.00	44.60
90.00	194.00	48.00	118.40	6.00	42.80
89.00	192.20	47.00	116.60	5.00	41.00
88.00	190.40	46.00	114.80	4.00	39.20
87.00	188.60	45.00	113.00	3.00	37.40
86.00	186.80	44.00	111.20	2.00	35.60
85.00	185.00	43.00	109.40	1.00	33.80
84.00	183.20	42.00	107.60	0.00	32.00
83.00	181.40	41.00	105.80	— 1.00	30.20
82.00	179.60	40.00	104.00	— 2.00	28.40
81.00	177.80	39.00	102.20	— 3.00	26.60
80.00	176.00	38.00	100.40	— 4.00	24.80
79.00	174.20	37.00	98.60	— 5.00	23.00
78.00	172.40	36.00	96.80	— 6.00	21,20
77.00	170.60	35.00	95.00	— 7.00	19.40
76.00	168.80	34.00	93.20	— 8.00	17.60
75.00	167.00	33.00	91.40	— 9.00	15.80
74.00	165.20	32.00	89.60	—10.00	14.00
73.00	163.40	31.00	87.80	—11.00	12.20
72.00	161.60	30.00	86.00	—12.00	10.40
71.00	159.80	29.00	84.20	—13.00	8.60
70.00	158.00	28.00	82.40	—14.00	6.80
69.00	156.20	27.00	80.60	—15.00	5.00
68.00	154.40	26.00	78.80	—16.00	3.20
67.00	152.60	25.00	77.00	—17.00	1.40
66.00	150.80	24.00	75.20	—18.00	—0.40
65.00	149.00	23.00	73.40	—19.00	—2.20
64.00	147.20	22.00	71.60	—20.00	—4.00
63.00	145.40	21.00	69.80		
62.00	143.60	20.00	68.00		
61.00	141.80	19.00	66.20		
60.00	140.00	18.00	64.40		
59.00	138.20	17.00	62.60		

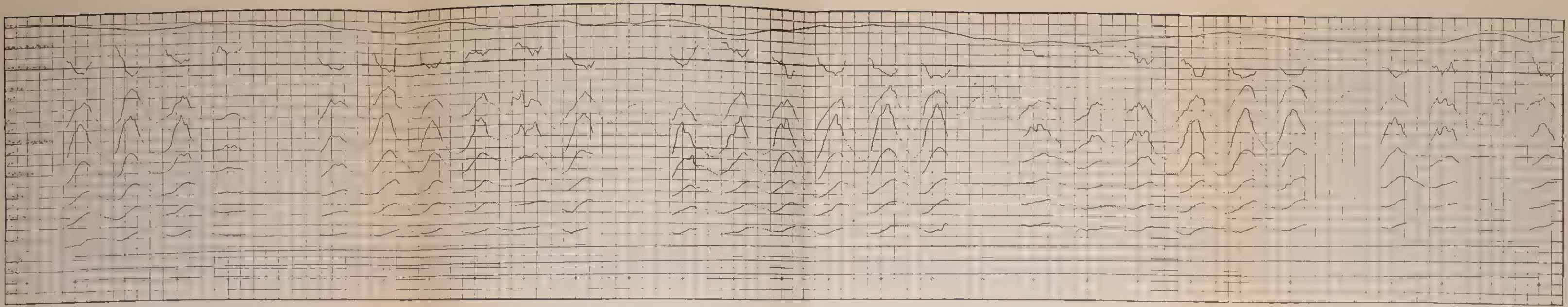
THERMOMETRIC RATIOS.

Reaumur .... 4°
Centigrade .... 5°
Fahrenheit .... 9°

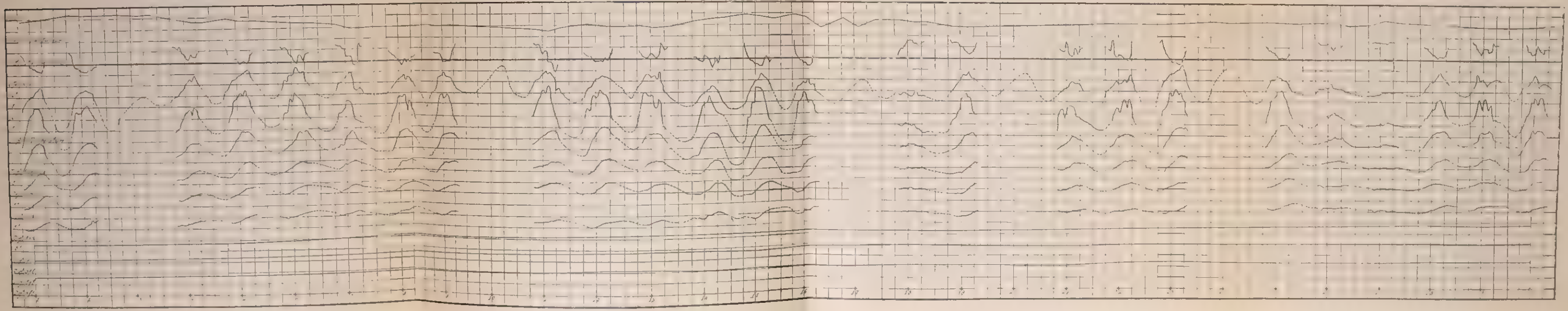
4 : 5 :: deg. R. : deg. C.
5 : 9 :: deg. C. : Deg. F.+32.

Converting to degrees Fahrenheit, add 32 degrees.

Converting to degrees Centigrade or Reaumur, subtract 32 degrees Fahrenheit before performing the operation.

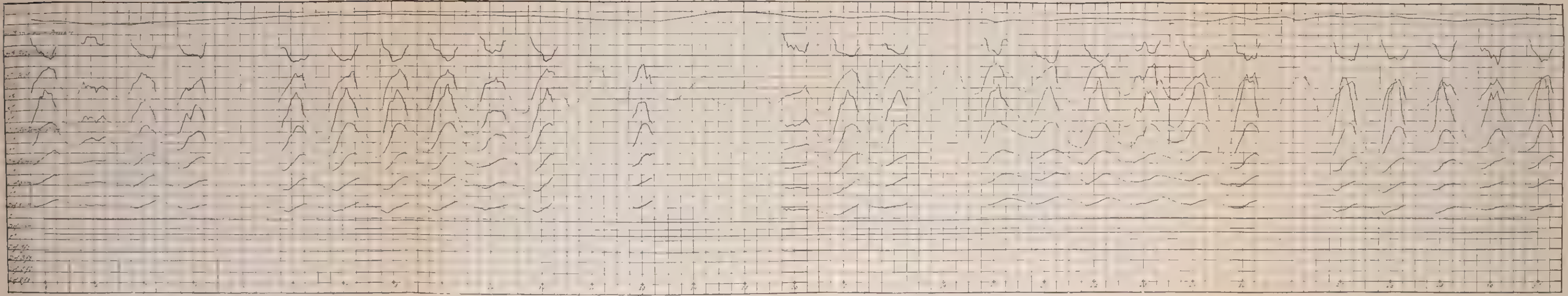


SOIL TEMPERATURES AND BAROMETER CURVES.
MAY, 1883.

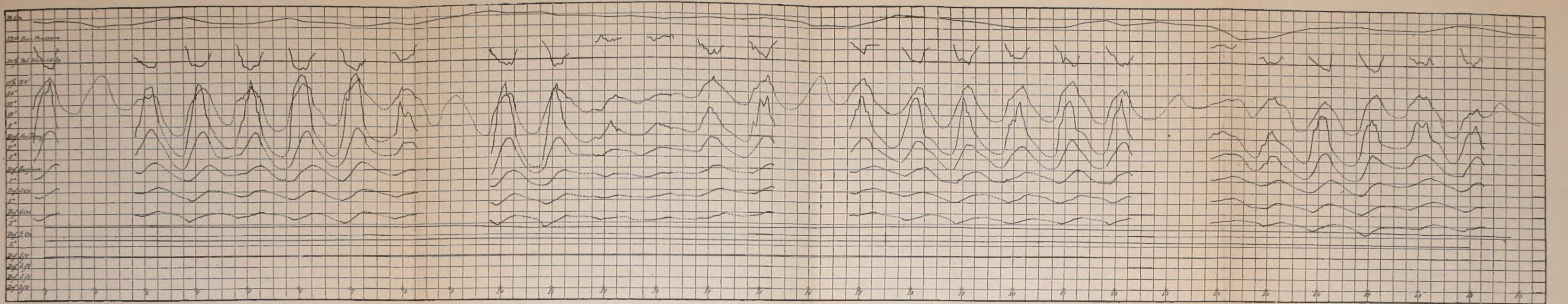


SOIL TEMPERATURES AND BAROMETER CURVES
JUNE, 1883.

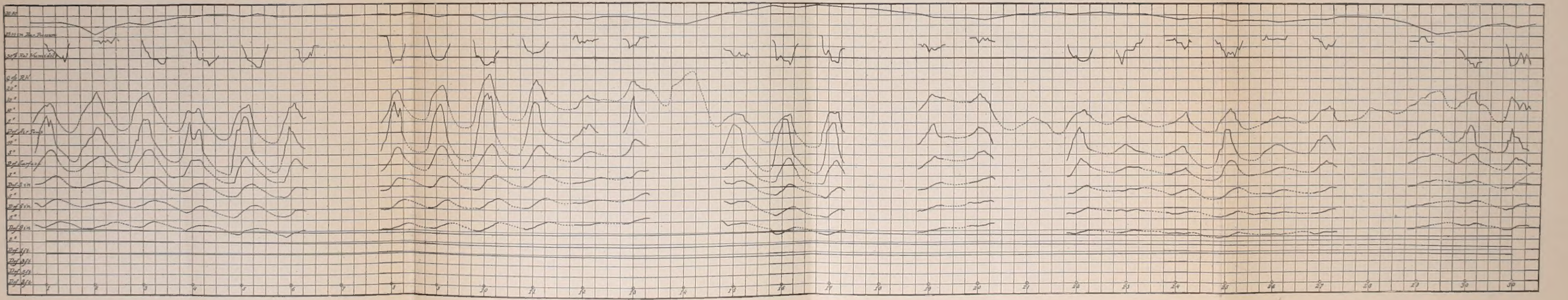
SOIL TEMPERATURES AND BAROMETER CURVES.
JULY, 1883.



SOIL TEMPERATURES AND BAROMETER CURVES.
AUGUST, 1883.



SOIL TEMPERATURES AND BAROMETER CURVES.
SEPTEMBER, 1883.



SOIL TEMPERATURES AND BAROMETER CURVES.
OCTOBER, 1883.

HOUGHTON FARM
MOUNTAINVILLE,
ORANGE CO.
N.Y.